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The Life of Wood Stave Pipe.

Most New England mill architects know by observation of timber penstocks in old mills that wood stave pipe will generally last many years if it is kept full of water. Such pipe was used in mills in New England a great many years ago and often had a longer life than other portions of the works constructed at the same time.

Consequently when stave pipe began to be used for water-works purposes on the Pacific Coast and in the Rocky Mountain district, the main novelty of this form of aqueduct was its length rather than its material. Experience in Denver and some other places has been very encouraging to advocates of this kind of pipe, but in a few localities the life of the wooden staves has been so short as to cause comment. For example, in a recent number of the "Proceedings" of the American Society of Civil Engineers, there was a paper by Mr. A. L. Adams, giving some facts concerning the condition of the Astoria, Ore., wooden pipe line built under his direction a number of years ago. The early failure of portions of this line is an important engineering fact, provided the circumstances producing it can be determined, but unless the circumstances are ascertained, the failure is not of interest, since there are many cases of wood stave pipes having extremely long life. For this reason it is gratifying to notice that Mr. Andrew Swickard, who is identified with the construction of such pipes, prepared a discussion of Mr. Adams' paper explaining the reasons for the failure of parts of the Astoria line. This information is particularly valuable, as it affords a hint to engineers who may contemplate the construction of such conduits but have not the benefit of practical experience with their maintenance.

The preservation of wood from decay depends upon absolute dryness, impracticable in a pipe line, or constant submersion in water, which can only be approximated. The resistance of wooden stave pipe to decay is accordingly dependent in part upon the amount of moisture in the outer portions of the staves, which would seem to depend in turn upon the pressure within the pipe, although a few engineers hold the contrary opinion. The necessity of keeping a conduit of wood stave pipe full of water is well shown by certain facts mentioned by Mr. Swickard. Most of the decay in the case of the Astoria pipe, for example, occurred at the high points along the line, indicating that the trapping of air at these places probably had a considerable injurious effect. Another case was that of a 30-in. pipe belonging to the West Los Angeles Water Co., which, during the winter of 1897-1898, was partly dry owing to a drought. The staves had rotted nearly through at a few places, and this rapid decay was more remarkable because they were redwood, which does not decay so quickly as many other woods. Another case was that of the Southern California Mountain Water Co., of San Diego, which had a similar experience with a 36-in. pipe line that could be kept only partially full during a very dry summer. Still another case was that of a pipe line of the Cheyenne water works built in 1890. About 9,000 ft. of Oregon fir stave pipe was used in this case, and its upper part was never full. In consequence some 4,000 ft. had to be replaced with sewer pipe. The remainder is not full all the time and is in an unsatisfactory condition.

Another factor which experience shows must be carefully investigated in connection with the determination of the causes of decay is the character of the wood used in the staves. Some species are much more durable than others; redwood is about twice as durable, in all probability, as Oregon fir. Moreover, wood varies greatly even when obtained from trees of the same species. If these trees have developed under the most favorable conditions, so that their growth has been fairly rapid and the timber is somewhat more open than that of trees grown where the conditions were more severe, than staves obtained from such trees are likely to decay more rapidly than those from trees grown under less favorable conditions. It has also been found that staves obtained from the butt-cut of trees are considerably better than those from the upper cuts. Such

things may seem mere refinements to those who are not acquainted with the great variation that exists in timber, but as experience is gained with wooden stave pipe, it will probably be found that success or failure under some conditions will be materially influenced by attention to these little details.

Still another factor which must be considered is the location of the pipe lines in situations that increase or decrease the probability of rapid decay. Experience has demonstrated that a pipe will surely have a short life if laid through a country where the conditions are such that decay is particularly likely to attack the timber. Portions of the Astoria line were laid through a forest where the air is moist during a large portion of the year, where rotten fallen timber is very common, and decay rapidly attacks wood exposed to it. Under such circumstances it is only natural, particularly if a pipe line is not subjected to considerable pressure which will keep the wood quite wet, that the staves should rot away quickly. Great injury to such lines is also likely to occur if the roots of trees or shrubs are allowed to grow about their surface. Mr. Swickard calls attention to a pipe line at Long Beach, Cal., where the roots of willows destroyed a portion of the line in a short time, although the other parts are in good condition. The same thing occurred on a part of the 30-in. pipe line of the West Los Angeles Water Co., previously mentioned as affected through a failure to keep it full of water during a dry season.

Attention is called to all these influences which may affect the life of a wood stave pipe line, because they are unlike those conditions which deteriorate lines of cast iron or steel. Every engineer knows that metal pipe conduits are likely to be seriously injured by a number of influences, and provision is made to counteract them so far as possible. In the same way provision must be made to prevent injury to wood stave pipes, and the fact that it has not always been made in the past is due in no large degree to a lack of experience with such conduits and consequently a lack of appreciation of those influences against which the engineer should guard in constructing such a line. There have been many excellent conduits of wood staves and they form a valuable part of the constructions at the command of the engineer. It is natural that there should be failures with them, for this is the case with all new methods of construction. A continuance of such failures, now that the cause of them is better known, is hardly to be expected, unless wood stave construction is employed in situations for which it is unsuited. It is conceivable that such pipe may be used to advantage even when it is known that its life will be short, but the deterioration of such conduits, foreseen when they were constructed, cannot be considered a failure in any engineering sense.

Second-Hand Machinery in the Power Plant.

In the design of a new power plant of large capacity the work is usually laid out several months in advance of the dates of machinery delivery promised by the successful bidders. The larger the organization, the more likely it is that even the minor details of the plant arrangement will be completed on paper before actual construction begins. To a considerable extent this is true of additions to existing power installations serving systems of magnitude. The growth of the business when carefully analyzed indicates long in advance the future need of equipment extensions; the addition of a single unit or two to the previous facilities of a great system is a relatively small matter as a rule, and plenty of time can be taken to plan such extensions in detail and to secure from the manufacturers the

latest type of machinery suited to the conditions.

Considering these facts, it is evident that second-hand machinery is in general less suited to the needs of very large plants than to the requirements of medium and small-size installations, although under some conditions the large plant may find the second-hand market peculiarly ready to serve it. Many causes have in recent years contributed to the growth of the second-hand machinery business, especially in relation to power installations. The three most important are undoubtedly the superseding of old equipment by that of greater efficiency, the rapid increase in the size of generating and even auxiliary units, and the wearing out of apparatus under severe conditions of service. In the central station field especially, plants built a decade ago were, in many cases, supposed to be large enough for twenty-five years to come, at least with a few modest additions in single units. Every engineer knows that the volume of traffic and output has transcended the conservative estimates of a few years back, and the resulting pressure upon the manufacturers is evidenced by the enlargement of their shops, lengthening of payrolls and increasing difficulty of securing prompt shipments in time of emergency. In respect to the main generating units of a large plant, it is in times of breakdown that the second-hand market stands the best chance of being useful, especially if there is a place for the temporary operation of units rated between 250 and 750 kw. Larger machines than these have not as yet found their way to any extent into the second-hand field. Sometimes even a small unit purchased second-hand in an operating crisis will tide over the worst weeks of the emergency in a large station, though regulation may have to be sacrificed and economy thrown to the winds. A recent mill plant breakdown occurred in which the loss on production was \$2,500 per day. By purchasing an old 1000-h.-p. engine in the second-hand market the mill was able to run until sufficient time elapsed for the proper repairs to be made, though the situation was a trying one on the score of economy. In such cases the cost of the second-hand unit is almost a matter of indifference, and the large plant which fails to scour the second-hand market for help in time of breakdowns of important machinery assumes a great deal of risk. The wisdom of buying second-hand machinery for a new plant of large financial resources is, of course, an entirely different question. The chances are that auxiliaries can oftener be supplied than large generating units, but the inquiry is worth making.

The broadest field of usefulness for second-hand power station equipment is in the smaller installations which serve communities that are sparsely settled or are incapable of supporting a thoroughly, modern layout of machinery on the business offered. It is a great deal better for the citizens of some remote town to receive the benefits of power and lighting service generated by second-hand units in a plant of unpretentious design than that no service whatever shall be available. It is inevitable that the smaller plants in the outlying districts should find in the second-hand apparatus of the larger city stations machinery excellently suited to their requirements. Neither the capacities nor the economies of the latest equipment are to be expected in the smaller installations. Many a Brush arc machine of rugged design and reliable performance is to-day operating in a small country plant with reasonable efficiency and at a first cost which would have been prohibitive to the community if a model alternating-current system with tub transformers and expensive switchboard outfits had been specified. Hundreds of engines long since discarded by city stations compelled to install high capacity units in the costly space available for power

generation are wearing out their later days in satisfactory performance under the less rigorous conditions of semi-rural service. The city plant gains in being able to dispose of its less essential equipment at a fair price, and the country station gains, when properly safeguarded, an installation which is workable at an investment cost which appears reasonable in the face of the anticipated traffic.

The physical side of the second-hand machinery problem is, of course, the most important matter for the purchaser to consider carefully. The same principles of selection enter here that bear upon the purchase of any second-hand appliance. A machine in first-class condition and of reasonably modern design has its legitimate price, which may be 20, 30 or 40 per cent. off its original cost, but it cannot be had at absurdly low figures from a reliable dealer. Inspection by a competent engineer should invariably precede the purchase of a second-hand machine, and the more that is known of its operating history the better. The practice of securing options upon machines before they are removed from original service and of making prompt inspections and possibly tests of service capacity, insulation, valve action and the like tends toward the final satisfaction of all parties concerned. No engineering problem demands keener judgment than the selection of a second-hand machine for power plant service.

Excessive Time Required for Contracts for Public Works.

The time required for the execution of many contracts for Federal, State and municipal public works in this country is notoriously excessive, and the costs of those works are correspondingly, though perhaps not proportionately, increased. These results are due to a number of causes. The formalities of one kind or another prescribed in connection with works of public character in addition to those required for private parties or corporations, are more or less cumbersome and lead to a distribution of responsibilities among a number of public officials, each necessarily jealous of his powers or obligations and all of whom must be fully satisfied before the work can be begun, even after the plans and specifications have been finished. When these preliminary but essential formalities have been completed and the work put in progress, its vigorous and effective prosecution is to some extent handicapped, even where all parties in interest are moved by the best of motives, by official red tape in transmitting many important instructions and much more by what is often a circuitous and slow method of payments. Cumulatively deferred progress payments and a growing interest account do not stimulate even the best and strongest contractors to rapid execution of work.

While the preceding delays are serious enough and tend inevitably to excessive prolongation of the work of public contracts, they are in general far less serious than the wearisome, multiplied and long-drawn-out procedures attending the final payments after completion of the contract. There are probably few contractors for the large public works done for the City of New York who could not give accounts of extraordinary delays in payment of final estimates, enduring months or even years after the satisfactory completion and acceptance of their contract works. These failures to make prompt settlement for work satisfactorily done are frequently largely due to failure to keep up accurate progress estimates of work performed so as to secure a final estimate concurrently with the completion of the contract no less than to the involved official routine necessary to secure the final payments.

Probably no one unfamiliar with these matters is aware of the amount of time consumed in these final settlements of public works contracts. It was but a short time ago that a contractor plainly in default for failure to prosecute his contract at the rate required by its provisions won his case against the City of New York wholly on the ground of the city's failure to pay with reasonable promptness the progress estimates for such work as he had performed prior to his default. Nothing could illustrate more forcibly the increased cost of work entailed upon the city by failure to pay progress estimates as well as final estimates without unreasonable delay.

While these observations are applicable to the execution of contracts for public works in general, they apply with special force to the municipal works of the City of New York, many of which are of unusual magnitude. Other things being equal, the greater the amounts of work to be done under contracts, the more attractive are such contracts and the smaller will be the unit costs. In fact, the municipal works of a great city are in themselves so composed as to lead to prompt and economic completion, and yet it is generally recognized that both the cost and time required for the construction of the public works of the City of New York greatly exceed the cost and time which would be needed for the construction of works of the same class and equal magnitude by any well-administered private corporation. It is equally well recognized that there are no more competent or experienced contractors in the country than many of those engaged on the public works in question. The equipment and organization of these contracting forces or agents are at least abreast of the best in the world for similar purposes. It is also a matter of common acceptance among experienced bidders for municipal work in New York that these elements of complicated red tape and official circumlocution must enter all tenders as increased costs, thus materially enhancing the prices bid. It would be a matter of much interest as well as of no little importance to the public to know how many millions of dollars have thus been added to the legitimate cost of works executed in New York within the past ten years only. This record would be worthy of extended comment.

It may be contended that the circumstances accompanying the necessary formalities of a more extended record for public works unavoidably increase the time required for executing contracts and possibly enhance the costs. These conditions, however, should be fully balanced if not overbalanced by the better credit of the city and by the certainty of the continued and increasing volume of work to be done in the future. As a matter of fact, under proper municipal organization and administration of public works, neither longer time nor more total cost should be involved in doing public than private work. As municipal affairs are now constituted, there is such a distribution of responsibility in constructing and paying for public works that it is practically "everybody's business," and what is everybody's business is nobody's business. Individual responsibility for work as a whole is annihilated and the spur of personal interest consequently disappears. There is no part of municipal administration requiring radical reform from a business point of view more than this. These considerations make it perfectly clear why a penalty clause for exceeding prescribed time limits for completion of contracts is practically impossible of enforcement. There is no legal cause or departmental order for much of the red tape at the bottom of the trouble. Heads of departments rely largely on subordinates who hold office under civil service protection and formulate rules and regulations to protect themselves, which usage and not law finally establishes firmly.

A Typical Hydraulic Power Development.

Some months ago The Engineering Record discussed editorially the value of water powers hitherto neglected or utilized only partly in a rough way for merely local purposes. It was pointed out that a large number of water powers unquestionably existed, even in the States settled for a long time, which could be made valuable by proper developments. Electric power transmission has removed the former insurmountable obstacle to the use of many good powers, namely, the necessity of utilizing the power at or near the site where it was developed; in fact, it is unnecessary to pay as much attention to the location of a mill using electric power as is the case with one depending on a steam plant. Although a number of hydraulic developments are described in each volume of this journal, the complete equipment of such an enterprise, including the electrical features, has not been explained for several years, and for this reason the works of the Southern Power Co., in the Piedmont section of South Carolina, have been described completely in a series of three articles completed in this issue. These explain what may be considered a typical development of the best class in the Southern Appalachian region. The section where this work is now in progress contains a number of enterprising and energetic cities which are developing varied manufacturing interests. The demand for power is constantly growing and the steady rise in the price of coal has naturally attracted attention to the possibility of utilizing the numerous powers along the Catawba River. The Southern Power Co. has undertaken this work, purchasing nine of these powers so located that it will be possible to interconnect them and distribute the power throughout the section containing such well-known places as Charlotte, N. C., and Columbia, Sumter, Spartanburg and Greenville, S. C. In addition to these cities there are many other smaller places which have good railroad connections and will doubtless be materially assisted in their development by the ability to obtain power at low rates. The enterprise is particularly interesting as typical of the class in which power is developed at a place where a good market already exists for it and the project is not dependent upon industrial establishments that are not yet in existence. In other words the power company simply enters into competition with the coal pile and does not have to become a real estate promoter. The various natural powers which have been secured are most of them somewhat larger than usual on streams of the character of the Catawba, and it is consequently practicable to build plants of sufficient capacity to insure low unit station costs. In the case of the Great Falls installation, which is the special subject of the articles, it will be noticed that the power house is situated in a particularly fortunate manner, so that the trouble which sometimes occurs in regulation where water must reach the wheels through long penstocks, is completely avoided. Moreover the head of 72 ft. is great enough to enable the units to be worked at a satisfactory speed from a mechanical point of view. In such respects the station at Great Falls is probably more fortunate than most installations, but in other respects it may be considered typical of the best general practice of the present time.

Attention is called to the unusually complete detailing in connection with the arrangement of the transformers. The fire risk connected with such apparatus is rather high, and in the Great Falls station special attention has been paid to diminishing it in a number of ways. Each transformer is in a compartment and piped so that the oil it contains can be discharged into the tail race. This arrangement insures safety to all transformers except the one in which fire may occur, but it does not prevent the destruction of that

particular transformer. Inasmuch as apparatus of this nature is quite costly, a further precaution has been taken to diminish the risk of damage to any individual transformer in case it should catch fire; for this purpose a carbon dioxide system has been added to the equipment, by means of which gas under pressure can be turned into any transformer case at a moment's notice. These precautions render it likely that no serious disturbance will ever arise through transformer fires. It should also be pointed out that the transformers are mounted on trucks, so that it is unnecessary to employ a crane, a feature of design which enables the high-tension wiring to be materially simplified.

So far as the transmission lines are concerned, it appears that the design in all its details is not closely in accord with the practice preferred by some electrical power specialists. For example, the use of solid iron wire is not regarded with favor by many engineers, for stranded wire is believed by them to give much less risk of breakage. The use of twin towers of steel on some circuits, which has also been employed in other plants, is also open to the criticism that anything which puts one line out of service is likely to destroy the efficiency of the other at the same time. Where the various stations are connected on the ring system, the objection is not so serious as in the case of plants depending on a single route. Nevertheless it seems to be the general belief that if duplicate circuits are considered necessary it is better to insure their independence by placing them on entirely separate pole lines far enough apart to prevent their simultaneous injury by the fall of limbs or a stroke of lightning.

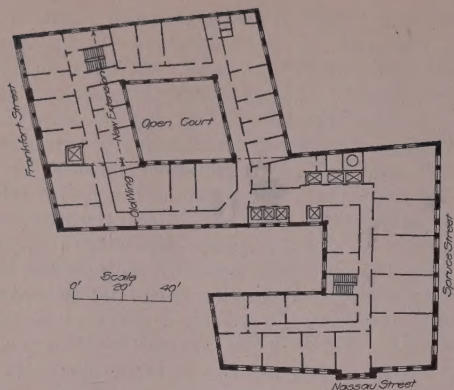
Notes and Comments.

THE GAS WAR in New York advanced another stage a few days ago, when the special master appointed by the United States court to hear testimony concerning the 80-cent gas rate law passed by the legislature filled a report indicating that the State acted unfairly in underestimating the actual amount of capital invested in the business of the Consolidated Gas Co. The official valuation of the property on which the rate of 80 cents was based was \$31,000,000, exclusive of franchise. The master reports that the property of the company is worth \$83,537,000, and that the actual cost of gas delivered at the consumer's burner is 65.84 cents instead of 48.63 cents, as claimed by the city and State officials. This report does not carry much weight, except as indicating that the gas companies have a strong ground for their contention that the 80-cent gas law is unconstitutional in being a confiscation of property without compensation. It is understood that the case will be carried to the Supreme Court at Washington in the quickest manner possible.

THE BINDER COURSE in asphalt pavements has long been recognized as their weakest feature as usually laid. It is accordingly interesting to learn from the valuable paper by Mr. Clifford Richardson, printed elsewhere in this issue, that municipal engineers are to blame if they continue to employ the old, unsatisfactory method of construction. A good many people have doubtless wondered why it was ever adopted, and it will be seen from the paper mentioned that it is merely a relic of a local legal complication in Washington. When it was decided to use asphalt instead of coal tar on the streets of that city, the law was such that it was necessary to have the pavements constructed within a certain unit cost. To render this practicable the base and binder courses which were previously employed with coal tar pavements were retained, and the asphalt was confined solely to the wearing surface. The pavement made in this way was fairly satisfactory

under the conditions of traffic which existed in the District, and accordingly no change was made. As asphalt was given tests under heavy traffic, however, the inadequate character of this binder course became apparent. It has been responsible for a considerable measure of the complaints against asphalt, and it is important to notice that at a trifling additional expense the troubles due to it can be avoided. Instead of using the old form of binder containing a large volume of voids which make it very unstable, it is only necessary to employ as the intermediate course a mixture of the same grade of stone previously used with the fine material forming part of the surface course. If this is done, Mr. Richardson states, the wearing surface can be reduced from 2 to 1½ in. in thickness except where it must carry the heaviest traffic, and the pavement made in this way will be materially superior to the old style having the coarse, intermediate layer. This construction presupposes, however, that the base of the pavement is durable and strong, in order that the best results may be obtained.

THE CONDITION OF FIRE HYDRANTS in Madison, Wis., has been criticised owing to the fact that a few of them were found frozen during the winter, and these criticisms have afforded the superintendent of the water-works department, Mr. John R. Heim, a text for some plain talk in his last annual report. At a serious fire about a year ago two hydrants were found frozen, so as to be incapable of furnishing water. In his report Mr. Heim states that one of these hydrants had been opened by a city employe without the permission of the water-works department, in order to use the water in thawing out ice from under an iron apron across a gutter. After use the hydrant was not properly drained and the freezing naturally occurred. The second hydrant which was found frozen had been manifestly broken after its last inspection by the application of needless force in closing it down, something that would never be done by an employe of the water department. This break allowed water to leak, and this water froze during the winter. In view of the fact that the city permits street sprinklers to draw water from the fire hydrants, allows steam roller attendants to take their boiler supply from them, and permits employes to use the water from hydrants for thawing out ice in gutters, it is manifestly unjust to hold the water department responsible for their condition, unless funds are provided for employing enough men to keep up an inspection of them constantly. In Madison this permission even goes so far as to enable contractors for concrete curb and gutters to take whatever water they need for mixing concrete from the fire hydrants. The liability to damage which such permission renders probable has been recognized by the Madison Water Board, and it has placed street sprinkling valves on about one hundred hydrants in order that water may be taken from them for other than fire purposes without touching the portions of the hydrants used in turning on fire streams. Attention is called to this experience because it again indicates the desirability of adopting stringent rules regarding the use of fire hydrants during the approaching working season. It is the custom in many places to allow city employes and some favored contractors to open these hydrants in order to secure water for a variety of purposes. This is entirely wrong, for the danger of allowing any but firemen and water-works employes to tamper with hydrants is a serious one. If it is necessary to furnish water from fire hydrants for other than fire purposes, the hydrants should be provided with what are known as street sprinkling valves which enable water to be drawn from them through special nozzles without touching the main vital parts of the apparatus.



The Extension of the Tribune Building, New York.

Since the first year of its existence the New York "Tribune" has been published at the corner of Spruce and Nassau St., near the entrance to Brooklyn Bridge. The first building that it occupied on that site was burned Feb. 5, 1845, and replaced within three months by a five-story brick building, which in 1857 was extended by a fire-proof addition 50 ft. square on Spruce St. In 1873 plans were prepared for a new building and the business of the paper was moved from the old portion of the structure to the Spruce St. portion, and the former was torn down to make

projected $2\frac{1}{2}$ ft. to carry the overhanging portion of the 18x18-ft. brick tower, which was provided with a granite balcony 150 ft. above the curb with illuminated glass clock dials 12 ft. in diameter above them.

Before the recent alterations the building had a front of 92 ft. on Nassau St. and a depth of 100 ft. on Spruce St., with a 32x120-ft. wing extending through to Frankfort St. It was built with self-sustaining brick walls laid in Portland cement mortar, carrying the ends of the floor beams and supported on extended footings on the surface of the sand about 20 ft. below curb level at a considerable distance above ground water level. The Nassau St. part is of very strong and massive construction with thick walls and heavy floors and with extremely wide and thick concrete footings, and has near the middle of the front a tall brick tower with footings of great width. The Frankfort St. wing is similar in construction to the Nassau St. portion, but is much lighter. Both of them were ten stories high to the foot of the two-story mansard roof.

It was recently determined to increase the height of the building to twenty stories and the problem was studied with great care in order to obtain a solution which would provide for the support of the thousands of tons of new structure on top of the old building integral with it, insuring an equalization of stresses in the old structure, providing for the addition of as much load to the old foundations as they could safely

sard roof and the exterior walls continued up vertically to the top of the twelfth story at the main roof and were left undisturbed for the new construction, the gable roof only being removed. On the remainder of the building the mansard roof was removed to the tops of the vertical walls at the tenth floor, where new construction commenced. In this part of the building the floor girders were carried on massive brick piers integral with the outer walls and the latter were so light that they had no bearing strength and were excluded from consideration as supports for the new superstructure. The tops of the old piers at the tenth floor were therefore covered entirely with grillage beams to distribute the loads from steel columns which were set on them and carried up to the top of the twelfth story, and served to support the floors and walls of the new intermediate stories replacing the old mansard roof stories.

At the height of the thirteenth story these columns carry parts of a system of horizontal distributing girders which extends over the tops of the old walls of the Frankfort St. wing and are also supported by bents, by an intermediate brick wall in the main part of the building, by the main tower, and by the new interior columns in the old part of the building. The girders in this system are so rigidly connected together and are so deep and strong that they are relied upon to distribute the load from one part to another, thus equalizing the load over the whole area. It is

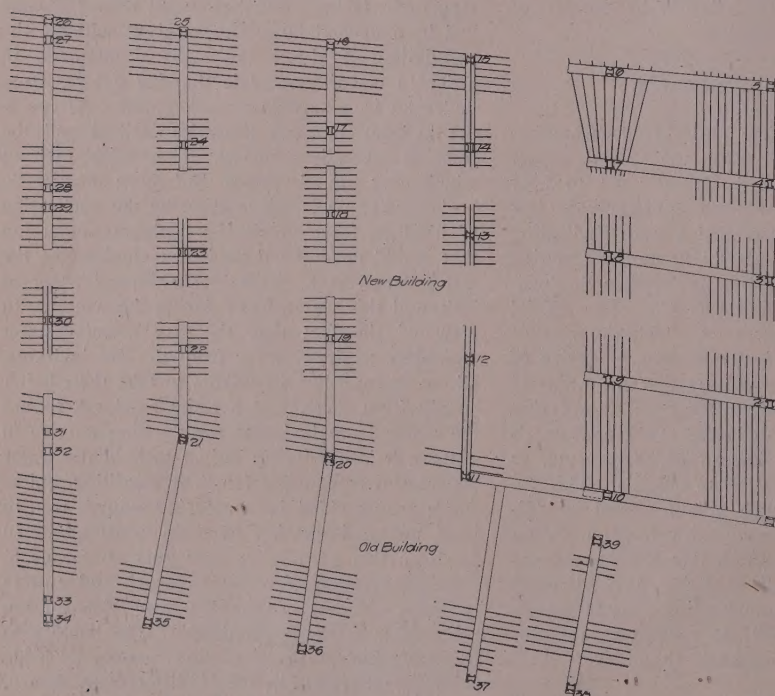


Diagram of Foundation Grillages and Girders.

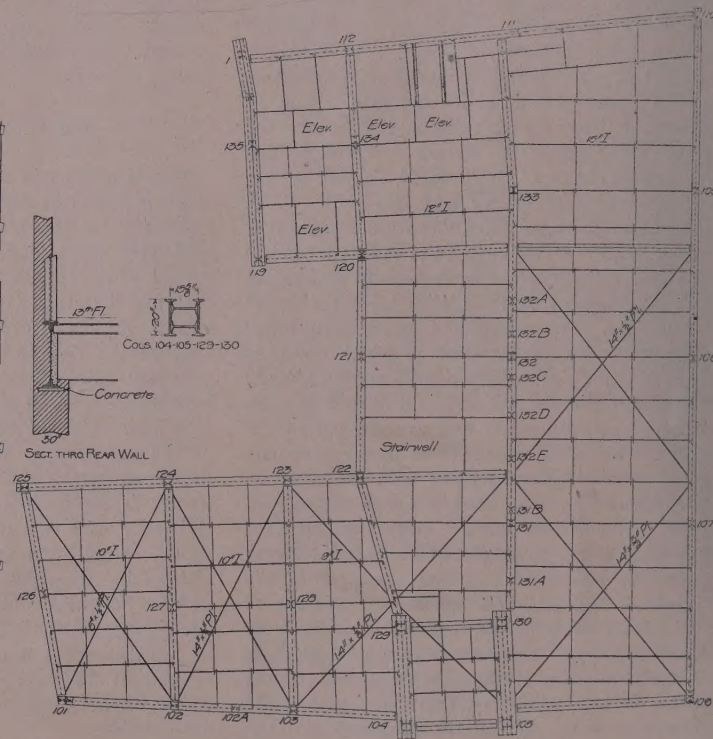
way for a ten-story brick building with a 92-ft. front on Nassau St. In 1882 the original plans were followed by the construction of an extension across the Spruce St. site to Frankfort St., which is now known as the Frankfort St. wing, and which trebled the size of the original building. The brick and granite walls carry the ends of the floor beams and at the foot have a thickness of 6 ft. 8 in., where they are supported on two granite courses with concrete footings 27 ft. below the curb. The masonry piers between the windows in the granite front are bonded together in the first story by three granite arches of the full thickness of 5 ft. 2 in. These arches were notable in that the joints of their voussoirs were made with molten lead.

Two ten-ton granite corbels 11 ft. long were built into the front wall at the fifth story and

carry, and for the construction of only as much new foundation as was necessary and for the execution of the work without serious inconvenience to the tenants.

A careful examination of the old footings showed that those of the Frankfort St. wing could not safely receive any additional loads, but that those of the remainder of the building had ample capacity to carry the entire additional weight imposed by the new stories above them. It was therefore decided to utilize the wall piers in the old part of the building to carry the additional loads down to the original footings and to provide independent new columns and footings in the Frankfort St. wing to carry the new loads in that part of the building independent of the old structure.

In the Frankfort St. wing there was no man-



Equalizing Girders at 13th Floor.

assumed that they provide a rigid base on which the seven upper stories of steel cage construction are built as if on an ordinary foundation at ground level. Their depths are so great that their deflections are very small, and if there is undue settlement at any point of support, or if some of the supports yield more than others from any cause, the loads will be distributed among the stronger and less yielding supports so as to practically equalize them and make all parts of the old structure work in harmony.

After the plans were well advanced for the extension of the old building the owners secured a 96x108-ft. lot adjacent to the Frankfort St. wing to the east and decided to build there a 20-story steel cage structure independent of the old walls and footings, but forming, so far as service and occupation goes, an integral part of the re-

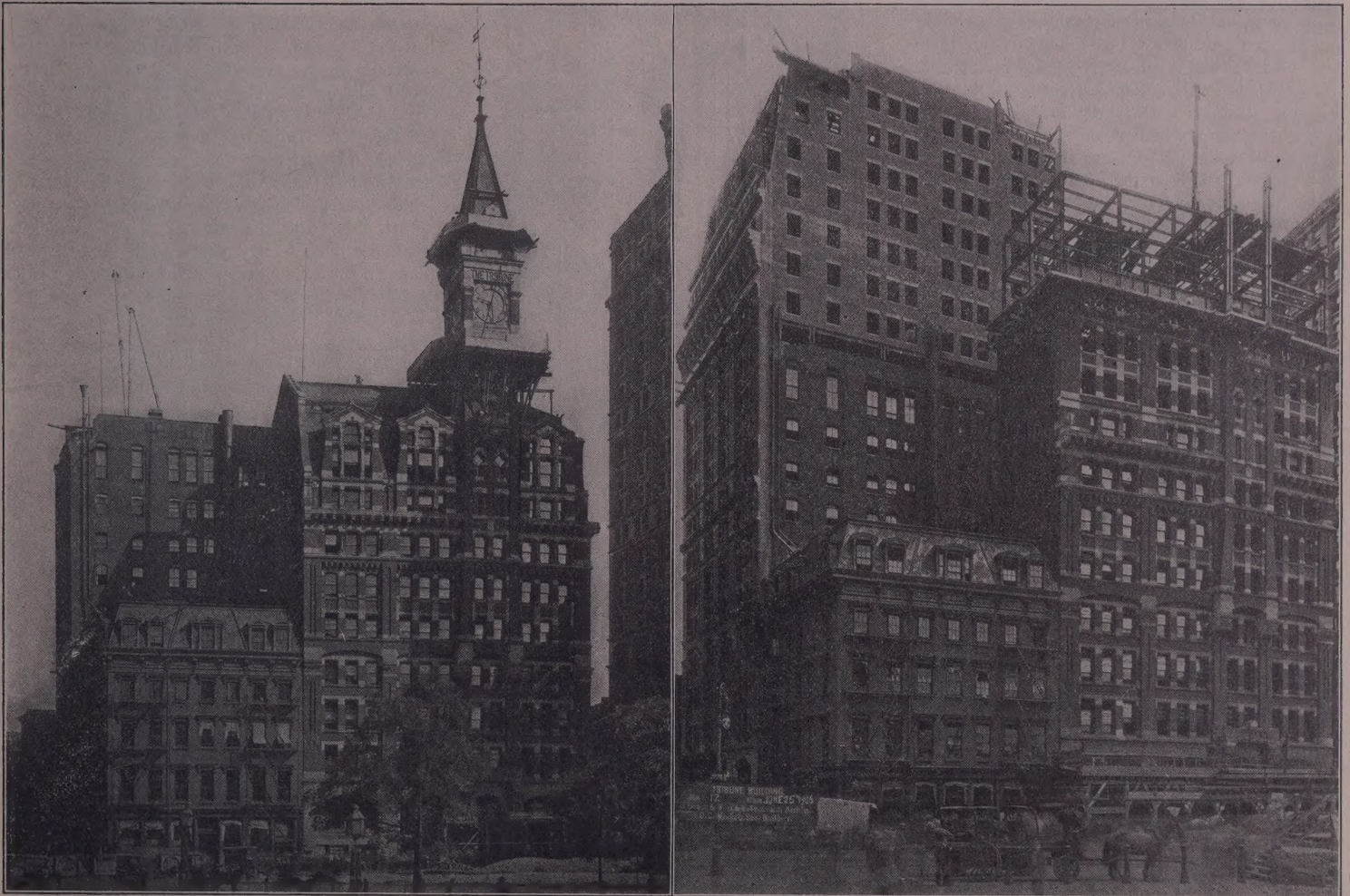
constructed and enlarged building. The analysis of foundations showed that three distinct conditions existed. First in the Nassau St. part where the sand was already under pressure, but could be expected reasonably to carry a considerably increased load. Second in the Frankfort St. wing where the sand was already under pressure and the existing foundations could not be loaded farther. Third, in the interior of the Frankfort St. wing where the sand between the old footings was under some pressure and was to be subjected to additional pressure from the new footings, and fourth, in the adjacent new part where the sand was entirely without pressure and new foundations were to be made and loaded.

It was ascertained that the foundations for the Nassau St. part of the building, although more than ample for the original load were very irreg-

ing to the thirteenth story, where they support the equalizing girders. In most cases these columns are braced at several stories to the floor beams and girders of the old building, but this connection is arranged in such a manner as to preclude the transmission of floor loads to them. In order to prevent injury to the old structure or the destruction of these connections by their displacement where settlement occurs under full loading, the connections are of a special type designed to permit vertical movement only and to maintain rigid transverse bracing. In part of the Frankfort St. wing there were structural difficulties in bracing some of the new interior columns to the old floors and as an unsupported height of over 150 ft. from the footing to the equalizing girders would have been utterly inadmissible the columns were built just beyond the

stresses safely to the ground. Lateral stresses are therefore distributed by a system of floor diagonals in the plane of the equalizing girders which are thus converted into a large horizontal truss distributing them uniformly over all parts of the old and new structures.

The footings for the columns of the new 20-story extension are carried down to a maximum of 5 ft. 8 in. below those of the Frankfort St. wing, so that to underpin them and temporarily carry the tall and heavy walls above them while the footings were extended a considerable depth and new foundations were constructed and loaded to take up the inevitable settlement was a very serious and costly problem. It was evaded, however, by a simple system of retaining the sand under the old footing, so that no portion of it could escape when the pressure was unbalanced



Views of Tribune Building before and during the Construction of the Additions.

ularly designed in that the unit pressures on them varied considerably. It was evident that increasing the loads on these footings would not cause as great a settlement as would be produced in the new footings to be built and heavily loaded on sand under no pressure and that still different settlements might be expected on new footings built on sand under some pressure. Great pains were therefore taken to compute the different settlements under these varying conditions as accurately as possible and so proportion the loading as to secure unit pressures that would produce as nearly as possible uniformity in the inevitable settlement, the amount of the settlement being a matter of comparative indifference while its uniformity was of the first importance.

Shallow excavations were made in the basement floor of the Frankfort St. wing and in them steel I-beam grillages were set on concrete footings carried down to the same level as the old concrete footings. New balance columns were seated on distributing girders across opposite ends of the grillage beams and were carried up without load-

outer wall of the wing and within the area of the new steel extension so as to be conveniently braced to its framework. In accordance with this requirement they are carried on special transverse foundation girders, which extend through the wing wall.

The entirely new 20-story extension and the seven upper stories over the old building are of the ordinary type of steel cage office building construction with closed rectangular columns, I-beam girders and floor joists and hollow terra cotta floors. Wind stresses are partially provided for with 8x8-in. horizontal connection angles to the top and bottom flanges of the beams and girders, making very stiff and rigid column connections capable of sustaining considerable transverse stress. It was calculated that the wind pressure from the nine-story new portion of the Nassau St. wing would be transmitted directly to the walls of the old structure and that the latter had abundant mass and strength, together with the stiffness provided by the floors and partitions to provide sufficient anchorage and transmit all

by the new excavation. This was accomplished by driving a continuous row of United States steel sheet piling 8 in. from the face of the old wall and thoroughly securing the upper ends with waling pieces well braced by diagonal struts. This precaution entirely prevented settlement or undermining while the new excavations were being made and care was taken to keep the braces in position until the new columns had been set and a considerable amount of the superstructure had been erected on them, thus loading the sand under the new footings to an amount approximately equal to the pressure on the opposite side of the sheet piles when the braces were removed and the ground being in equilibrium left no apprehension for difficulty with either set of foundations.

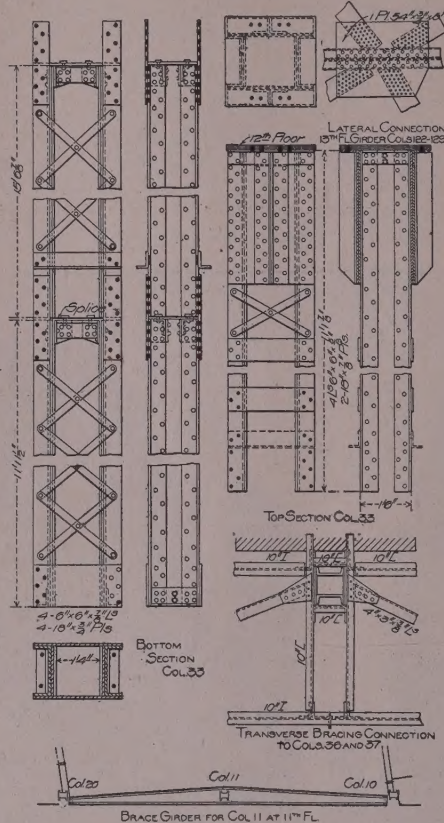
The grillages for the new columns consist of 12 to 24-in. I-beams imbedded in concrete and set on a concrete footing 25 ft. below the curb at the bottom. In all cases they have distributing girders perpendicular or nearly perpendicular to them at about their center points to receive the

column loads and transmit them equally through all of the beams. In some cases three 24-in. I-beams serve as the distributing girders, but in most cases the latter are box plate girders with two or three webs shop riveted complete and put in place as single units, the largest of them being 28 in. wide and 56 in. deep and 32 ft. long. Adjacent to the old structure and in the opposite wall it was necessary to carry the columns as close as possible to the lot lines, and the distributing girders therefore act as usual under such circumstances as cantilever girders providing for the eccentricity between column center and grillage center, and receiving at the opposite end an interior column which provides for the upward reaction.

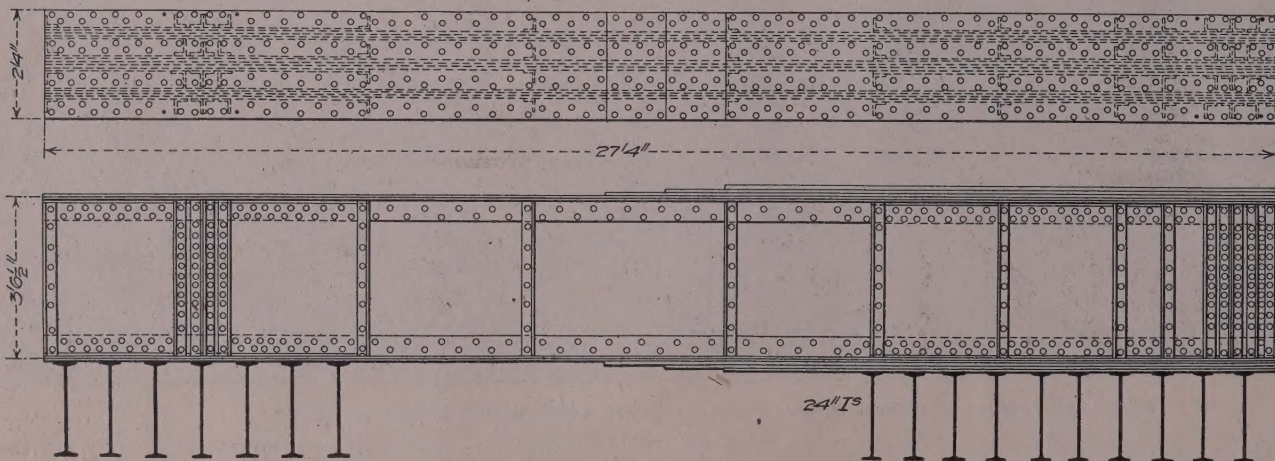
As the grillages in the old building could not be located directly under the columns which they support, it was necessary to place them wherever room could be found between the existing foundations and to support the columns from them with long cantilever girders, counterweighted in two cases, by wall columns Nos. 20 and 21 of the new structure. Here the arrangement was somewhat different in that the end of the girder in the new building projects through the outer wall and is seated on the cantilever end of the girder in the new part of the building and transmits to the latter the load from the wall column in the new building, which is seated on its top flange. The girder which carried column 37 in the old building could not be made to connect directly with the main distributing girders in the old building, but its end was similarly carried through the wall of the old building and web-connected to a special box girder parallel with the wall that is seated at one end directly on the top flanges of the grillage beams and at the other end is seated on the top flange of the distributing girders which carry new columns Nos. 1 and 10.

Another interesting arrangement is that for the girder which carries columns 31, 32, 33 and

The girder carrying columns 2 and 9 is typical of the distribution girders and is 27 ft. 4 in. long, 28 in. wide and nearly 4 ft. deep over all. It is made with full length 42x $\frac{3}{8}$ -in. side web plates and a 42x $\frac{5}{8}$ -in. center web plate, the former each being reinforced at each end over the bearings with two 40x $\frac{3}{8}$ -in. cover plates. Each flange is



Special Column Construction and Bracing.



Foundation Girder 2-9.

34, and is supported by a central grillage between the two groups of columns which carries most of their load and by a small grillage at one extremity which carries only a fraction as much. The foundation plan, although worked out in conformity with the recognized principles usually governing grillage footings, is in this building very interesting on account of the care and ingenuity exercised in securing a simple construction under difficult circumstances and providing for the different proportions of load which it was calculated should be distributed over different parts of the area in order to secure uniformity of settlement in the completed structure. In all of the larger grillages the I-beams, which are everywhere connected by gas pipe separators and tie bolts are arranged in units of three or four beams each, but adjacent units are not connected together by tie bolts.

made with four 6x6x $\frac{3}{4}$ -in. angles, one full length 38x $\frac{1}{2}$ -in. cover plate and two shorter 28x $\frac{3}{8}$ -in. cover plates. The stiffener angles are pairs and double pairs of 4x3-in. and five 3 $\frac{1}{2}$ -in. vertical angles with their ends bearing against the flange angles and are riveted on both sides of the center web and on the outsides only of the outer webs. Under the column bearings they are spaced as closely as possible together and are set back to back making a T-shaped cross-section.

Column 33 in the Frankfort St. wing is made, in the lower stories, in single story lengths with a rectangular cross-section made up with 18x $\frac{3}{4}$ -in. web plates and four 6x6x $\frac{7}{8}$ -in. flange angles. The webs are spaced 16 in. apart to clear the existing girders which pass between them, and have wedge bearings on interior brackets on the columns. The columns are spliced with horizontal diaphragm plates and field-riveted flange

cover plates. At the upper end of the twelfth story section the flanges are connected by wide shop-riveted cover plates, having on the outer faces pairs of vertical stiffener angles, back to back, with their upper ends milled to bearing on the flanges of a horizontal cap plate receiving the ends of two of the thirteenth floor equalizing girders.

Column 11 in the new portion of the building is located close to the outer face of the old wall of the Frankfort St. wing and is in the middle of one side of the 34x39-ft. light shaft, which forms such an important feature in the construction of the new part of the building. It carries floor loads from the ten upper stories in the extension above the old building, but on account of its position in the light shaft is not subjected to any loads from the new building itself and consequently is not connected to the floor beams and floor girders there. It would therefore, unless specially braced, be entirely without lateral supports up to the tenth floor, thus making an isolated column about 150 ft. high and producing an entirely unallowable ratio of length to radius of gyration. In order to reduce this ratio and divide the columns into sections of suitable length, it is braced at alternate stories below the tenth floor by horizontal web plate girders about 38 ft. long with one straight flange in contact with the face of the party wall and the other flange bent to enclose the column at the center point of the girder. The ends of the girders are field-riveted through horizontal connection angles to columns 10 and 20, in the opposite walls of the light court between which the girder is continuous with its horizontal web engaged between the adjacent ends of successive sections of column 11, which are field-riveted to it through horizontal connection angles.

The new columns in the old building, adjacent to the walls of the latter, do not carry any loads below the thirteenth floor and in order to give

them lateral support at intermediate points and thus maintain their column efficiency, they are as previously stated provided at every floor with bearings fixed horizontally through which they can move vertically without transmitting any stress to the adjacent structure, thus providing for the inevitable settlement which will occur when they have received their final loads. This arrangement is effected by providing in each floor a vertical sleeve through which the column passes with very slight clearance and which is itself a panel point in the regular truss formed by riveting perpendicular and diagonal members to the beams and girders of the old floor system, as is shown in the cross-section of columns 36, 37, where the 10-in. I-beams are part of the old floor construction, and all the rest of the steel work is new.

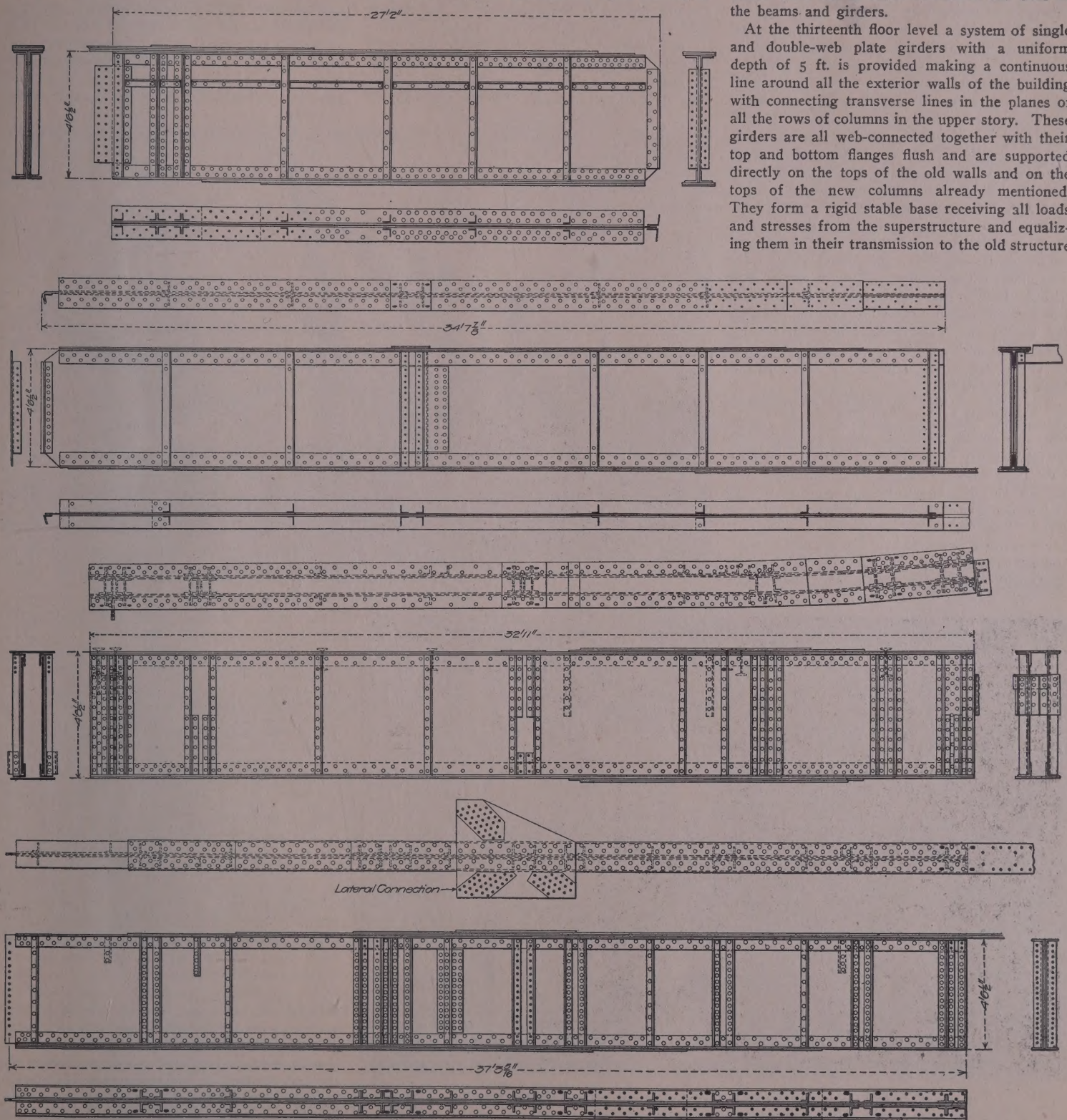
The new column is enclosed in a horizontal

rectangular framework of 10-in. channels with the backs of their webs engaging its cover plates and the edges of its flanges so closely that light can scarcely be seen between them. The rivets in the columns being, of course, countersunk at this point.

as if upon a foundation at ground level. This involves the reconstruction of three stories of walls at the point where the mansard roof had been and in order to diminish to the utmost the additional weight placed on the old foundations these were built as thin curtain walls carried at

cement mortar on the carefully leveled surface of the brickwork and afterwards completely enclosed in the new masonry. The brick tower in the Nassau St. front has walls so massive that they are competent to act as columns and recesses were cut in them to receive the ends of the beams and girders.

At the thirteenth floor level a system of single and double-web plate girders with a uniform depth of 5 ft. is provided making a continuous line around all the exterior walls of the building with connecting transverse lines in the planes of all the rows of columns in the upper story. These girders are all web-connected together with their top and bottom flanges flush and are supported directly on the tops of the old walls and on the tops of the new columns already mentioned. They form a rigid stable base receiving all loads and stresses from the superstructure and equalizing them in their transmission to the old structure



Equalizing Girders.

As already stated, part of the walls of the old building were of solid brick masonry up to the twelfth floor and part of them were of solid brick masonry up to the tenth floor, where they received the mansard roof framework extending up to the higher level. The former were extended by means of brick masonry to the under side of the thirteenth floor girders and the latter were extended to the same level by means of steel columns resting on grillage bases, which cover the area of the old brick piers at the tenth story. The thirteenth floor girder system formed a foundation upon which the additional stories are built.

every story on steel girders supported by short columns seated on the tops of the old brickwork.

The columns are located on the old piers integral with the original walls and carrying the main girders in the lower stories. The upper ends of the columns carried the system of thirteen floor girders on which the main superstructure is erected. These columns have maximum loads of as much as 474,000 lb., and in order to distribute the pressure uniformly over all of the available brickwork, which was considered competent to carry additional loads, their bases are set on grillages of 15-in. I-beams embedded in

which now becomes the sub-structure and carries them to the ground.

Wind stresses in the superstructure are provided for in the usual way by the depth and stiffness of the floor beam and girder connections, by the mass of the superstructure, and by the strength of the floors and partitions. They are distributed through the equalizing girders by horizontal diagonal members in the planes of their top flanges, as indicated by the general diagram, which are intended to distribute them so fully over the entire area of the building that they are absorbed by the walls and floors of the old

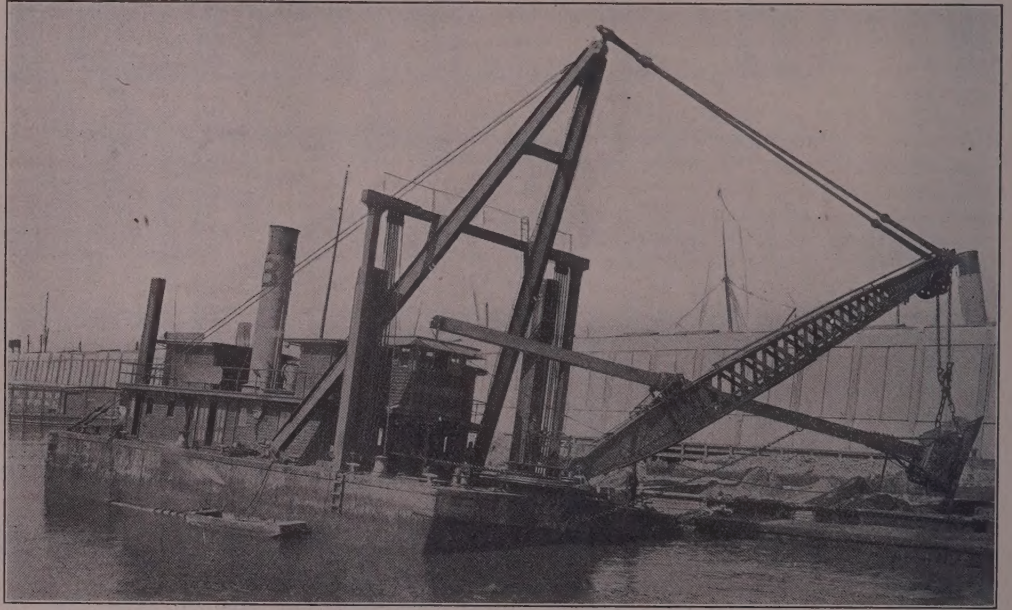
structure in the same manner as the wind pressures originally experienced by it, without producing undue stresses there.

The design and details of the equalizing girders vary considerably on account of the irregularity of the old wall and the principal modifications necessary to make their planes coincide with the center lines of the columns. One of the heaviest girders is the wall girder reaching across the wing and carrying corner columns 1 and 119 and intermediate wall column 135. It is made with two 54x $\frac{3}{8}$ -in. full length web plates spaced about 7 in. apart back to back. Each flange is made with two 6x6x $\frac{1}{2}$ -in. angles and one 20x $\frac{3}{8}$ -in. full length cover plate, besides which there are additional short 20x $\frac{3}{8}$ -in. and 24x $\frac{3}{8}$ -in. cover plates at the point of maximum moment. The girder is rather peculiar in that the vertical legs of the flange angles are riveted to the inside of the web plates, thus permitting vertical stiffener angles to be riveted to the outer sides of the web plates without fillers. Pairs of angles close together back to back are riveted to the web with two vertical rows of open holes to their outstanding flanges for field-riveted connections of the intersecting girders which engage them with pairs of jaw plates at one end and with an oblique angle at the other end.

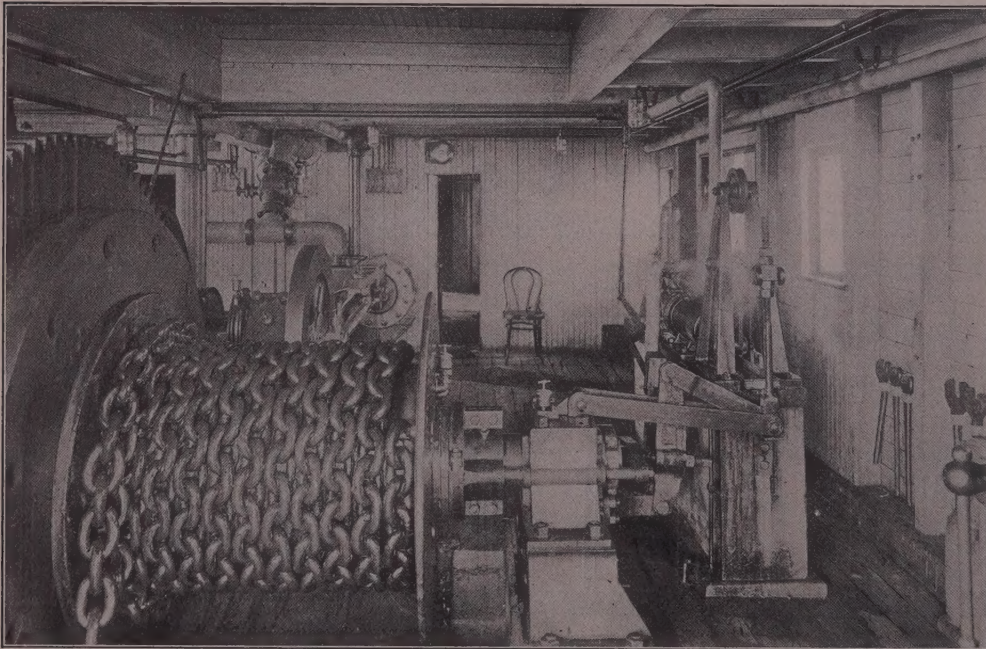
The girder making the oblique connection is an ordinary single web plate girder 34 ft. 7 $\frac{7}{8}$ in. long over all with its bottom flange seated directly on the masonry of the old wall at thirteenth floor level. It carries thirteenth-story column 112 near the middle point and at the opposite end is web and flange spliced to another girder in the same plane. The web splice is made with a pair of cover plates shop-riveted to one girder and field-riveted to the other and the flange splices are made with long extensions of the bottom flange

flange. A horizontal shelf angle is riveted to one side of the web just below the top flange angles to receive the brick floor arches. The girder connecting wall column 122 and interior column 129 (girder 122-129) does not actually connect the two columns at its opposite ends by which it is designated, but is web-connected to the girders which carry them and is oblique to both of them. It is a perfectly simple plate girder with reinforced flanges and with a bent angle connection at one end. At the other end there is a single row of field-driven rivets through the web for

bottom flange plates field-riveted to one girder and shop-riveted to the other, so as to virtually make a thoroughly continuous girder with undiminished web and flange sections at the splice. This girder is seated on the tops of five columns which bear upon the old wall at the tenth floor level and supports two fourteen-story columns. At each column bearing the web is stiffened with two pairs of vertical angles having their flanges turned outward and spaced at the ends to bearing on the flange angle. Near one end a thick connection plate is riveted to the top flange to receive the



The Dredge "Independent" of the Bush Terminal Co.



Port Main Friction Drum and Steam Nip on the "Independent"

projecting beyond one girder to which they are shop-riveted and field-riveted to the other girder and with corresponding projections of the top flange reversed from the second girder to the first. The web is stiffened by two pairs of vertical flanges with their outstanding flanges turned away from each other so as to receive between them the vertical connection angles of the intersecting girder, which are field-riveted through the flanges of the angles on the first girder. The adjacent girder carrying columns 110 and 111 corresponds substantially with the one last described and is 27 ft. 2 in. long over all with two 11/16x 14-in. cover plates nearly full length on each

a bent plate connection to the end of the triple web girder seated on the heavy wall of the tower. Near this end a 54x $\frac{3}{4}$ -in. plate 5 ft. 7 in. long is shop-riveted to the top flange to receive the four 14x $\frac{7}{8}$ -in. diagonal lateral plates, which are field-riveted to it with about thirty-five $\frac{3}{4}$ -in. rivets in each.

Girder 130-132 is typical of the interior equalizing girders, but is special in that it has at one end an offset connection to the triple web tower girder to which it is field-riveted in a single row of vertical rivets through its web. At the opposite end the splice is made as already described with web cover plates and projecting top and

field-riveted ends of three 14-in. lateral diagonal plates.

The old building contained besides the offices of the newspaper over 150 rooms for rental. The two lower stories of the new building will be entirely devoted to the requirements of the editorial and publishing departments of the paper, which will have much increased facilities and enlarged space and all of the upper stories will be available for renting space, and will comprise about 535 typical offices. The building and its new extension will occupy about 16,000 sq. ft. in horizontal plan and will have a total height of 231 ft. 4 in. from the sidewalk to the top of the flat roof and 335 ft. to the top of the finial of the tower. The old and new portions of the building, although of different types of construction will form a single finished unit and will be served by a single installation of mechanical equipments, including eight plunger passenger elevators, a 1,000-h.-p. battery of Babcock & Wilcox boilers, 35,000 sq. ft. of direct steam radiation divided into 1,000 units, a fresh air supply operated by a 120-in. fan driven by a 13-h.-p. direct-connected motor and controlled by Johnson thermostat besides a separate ventilating system for the melting pots on the type-setting machines.

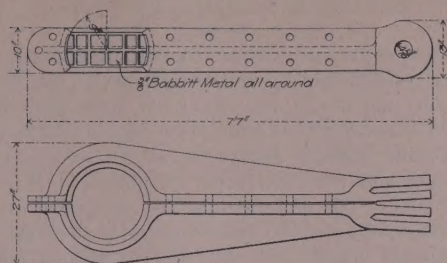
Mr. George E. Low, 45 Broadway, New York, is the consulting engineer, Messrs. D'Oench & Yost and L. Thouvard are the architects. D. C. Weeks & Son are the general contractors. Post & McCord are the sub-contractors for the steelwork. Some of the new columns in the old building were furnished by Pierson & Goodrich. The Osborn Engineering Co., of Cleveland, O., and Mr. H. W. Brinkerhoff, New York, were employed by Mr. Low for special engineering services in connection with the steel design and foundation problems.

AN 800-FT. TIMBER TRESTLE, 165 ft. high, has recently been erected near Boone, Ia., by the Ft. Dodge, Des Moines & Southern Ry.

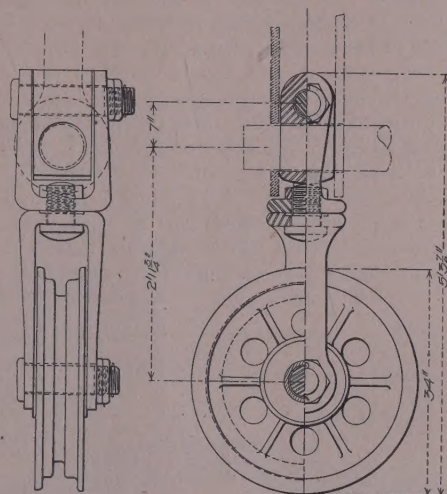
The Dredge "Independent."

The $4\frac{1}{2}$ -yd. dipper dredge, "Independent," owned by the Bush Terminal Co., of New York, and used constantly since September, 1906, in the extension of its docks in South Brooklyn, was built specially for slip work. The hull is 90x38 ft. 2 in. by 12 ft. deep and unusually heavy. The main house is 52x28 ft., containing a main engine room, crew's dining-room, officers' dining-room, kitchen, washroom and toilet. On the upper deck, forward, is the operating room and three cabins for the captain, engineer and steward. On the upper deck, aft, is a 16x16-ft. bunk house for eight men. All the rooms can be heated by steam.

The main hoisting engine is of the double-cylinder, double-drum type, placed on the main deck, forward. The bed plate is extended in front and carries the inner bearings of the large spur wheels. These wheels are thus made an integral part of the engine and the maintenance of a proper relation between the pitch lines of the spur wheels and the pinions on the main crankshaft is assured. The engine cylinders are 16x18 in. The drums are all actuated by cork-inserted frictions. These frictions are the standard Lidgerwood type made of hard wood turned to a truncated cone section and working against a female surface of turned cast iron. Three-quarter-inch holes on 2-in. centers were bored in the faces of the wood and corks pressed into them. The holes are staggered so that the corks cover the whole metal surface of the female section as the friction revolves.



Head Socket of A-Frame.

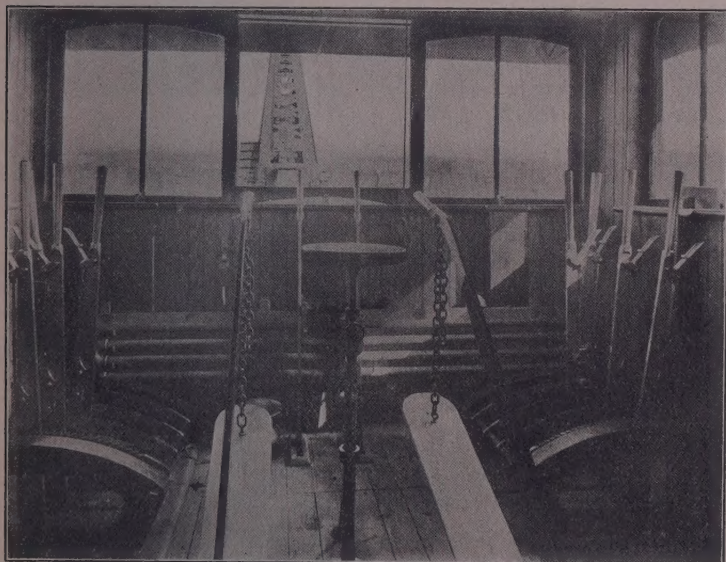


Universal Joint and Boom Sheave.

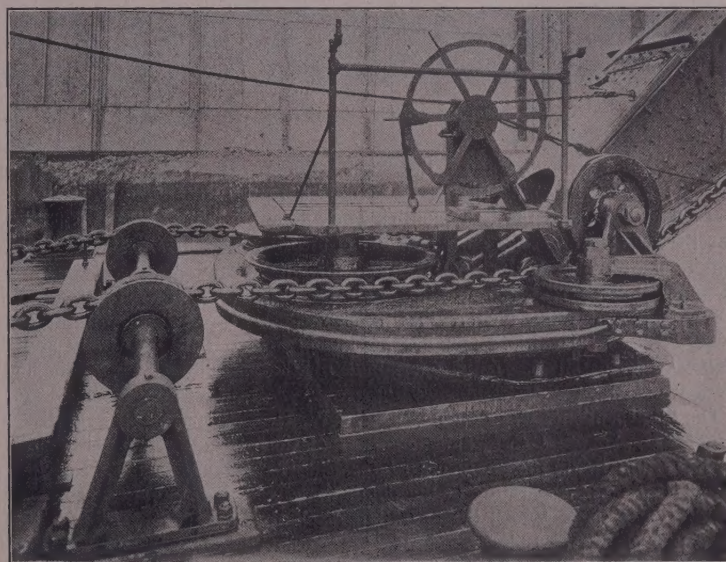
by carrying in stock only one spare piece of each of the parts subject to the greatest risk of breakage. For instance, the bevel pinions are intentionally selected as the breaking pieces for the capstan gear. There are four of these, yet only one carried in stock is necessary to provide for quick repairs.

The boiler is of the Scotch marine type 11 ft. in diameter, 12 ft. long, and has two 42-in. corrugated furnaces. There are three 4,000-gal. steel water tanks in the hold, one on each side and one near the stern. The last is always kept full as a reserve supply and for ballast. There are two double-cylinder Blake steam pumps, one for the boiler feed and the other to pump from the bilge, from a water boat or from the tanks.

The boom is built of angles, cover plates and lattice bars in the usual manner, and is 53 ft. 2 in. long over all. The head sheaves are attached by a specially designed compact universal joint shown in an accompanying illustration, which gives the wheels freedom of motion in every direction and prevents the breakage of the flanges which sometimes occurs when a less flexible connection is used. The leads from the tip of the boom to the top of the A-frame are attached to the latter by a ball and socket joint. This joint, the details of which are also illustrated, is in effect as if the two leads met at one point. Torsional strains in the boom are thus avoided when the boom swings to one side or the weight on the lifting chains is unequal. The four guy cables are $1\frac{3}{4}$ -in. plow steel. The dipper is of the usual type and the 58-ft. handle is made of a 16x



Operating Room.



Roller Friction Turntable.

It is stated that the cork surface about doubles the holding power of the friction and maintains the grip even if grease gets on the surfaces. It is believed that this is the first time cork inserts were used in dredge work.

In the hold is the backing drum, operated by a wheel which meshes into one of the large spur wheels of the main drums. The frictions of these three drums are set up by steam nips built with wrought-iron toggle levers and actuated by an Osgood patent steam grip cylinder. One of these is shown in an accompanying illustration. The form of this grip is novel. The thrust on the main drums and backing drum is transmitted from the thrust collar to the drum through a special roller bearing made by the Philadelphia Roller Bearing Co. These were adopted to reduce the frictional losses incident to the ordinary arrangement and also avoid the cutting of a keyway through the main shaft. They have proved very satisfactory.

A double-cylinder, 10x12-in. engine is placed

in the hold forward and the fore and aft spuds on both port and starboard sides are operated by it through friction drums. The spur wheel shaft extends clear across the hold. Near each end it has a pinion which engages two spur wheels, one on each side of the shaft, each of which is connected with a friction drum. These four drums carry chains leading to the four spuds. At the extreme ends of the main shaft are bevel gears through which power is transmitted to two forward gipsy winches on the main deck. The two stern gipsy winches are operated by a separate $6\frac{1}{4}$ x9-in. double-cylinder engine, the power being transmitted through bevel gears as for the forward winches. All the speed drums and their gearing are interchangeable. This includes four drums, their shafts, frictions and other details, the bevel gear wheels and pinions operating the capstans and the capstans themselves. This reduces to a minimum the possibility of delays and cost in making repairs in case of breakdowns and making it possible to be ready for repairs

16-in. Oregon fir stick and four 6x6x $\frac{1}{2}$ -in. angles. The handle is built under the Howard patent. The four angles of the timber are reinforced by 6x6x $\frac{1}{2}$ -in. angle irons riveted through and through.

The turntable is carried by eight conical wheels attached to the movable or upper plate and rolling on a fixed circular track. The horizontal thrust is taken by twelve vertical cylindrical rollers, equally spaced about the circumference of the moving plate and attached to it. These rollers bear against the outside of the same rail that carries the weight. This turntable is operated with much less power than those of the usual type where the friction is sliding. The wheels can be removed without unshipping the turntable.

The operating room is arranged so that the captain can control all the movements of the dredge without moving from his position. He can also control the forward gipsies, but the after ones, operated by a separate engine, are manipulated by the crew. Reading from right to left across the picture of the operating room the various

levers are as follows: Starboard after spud brake, starboard after spud friction, starboard forward spud brake, starboard forward spud friction, starboard main drum friction, main throttle, spur engine throttle, port main drum friction. The four remaining levers on the port side operate the port spuds and are arranged like those on the starboard. The seat in the center is attached to a vertical sliding shaft and by putting his weight on it the operator sets the friction on the backing chain drum.

The dredge is equipped with an electric lighting system, current for which is generated by a $7\frac{1}{2}$ -kw. General Electric generator direct-connected to a small vertical engine. The wiring is carried in loricated conduit as in government naval work. A special system of piping with hose connections is provided for fire protection, the bilge and tank pump being arranged so that it can pump salt water for this purpose.

The "Independent" is at present dredging a slip at the foot of 49th St., Brooklyn. In eight months, which included all the winter months, 168,000 cu. yd. of mixed material has been taken out, consisting of about 56 per cent. of sand, 43

The Hell Gate Bridge, New York.

One of the most interesting parts of the great improvement which the Pennsylvania R. R. Co. is carrying out in the vicinity of New York is the bridge over Hell Gate. Few people recognize that the tunnels under the North and East Rivers and the great terminal station in Manhattan are but a portion of the comprehensive improvements which the company is now executing in New York. Mr. Cassatt pointed out in an article, printed in the Current News Supplement of this journal on Jan. 27, 1906, that necessarily connected with the traffic due to the tunnel line into Manhattan are the developments of the passenger and freight facilities of the Long Island R. R. in Brooklyn and Queens and the proposed construction of the New York Connecting Railroad. By means of its bridge over the East River, the latter line will establish for Brooklyn and Queens direct railroad communication with New England and the north. The Connecting Railroad will be 12 miles long, running through a part of Queens Borough as yet half rural, although recently much developed by

structure, and associated with him was Mr. Henry Hornbostel, consulting architect. Mr. Lindenthal's conception is that of an imposing portal, or gateway, from the Sound into the East River, just as the Brooklyn Bridge forms a gateway from the harbor.

The arches will be erected in the same manner as the double cantilever bridge on Blackwell's Island. The carrying capacity, it is understood, will be equal to four trains of the heaviest freight locomotives. The bridge will be of the riveted type and about three years will be necessary for the completion of the whole work.

Of the four tracks, two will be for passenger and two for freight traffic. The passenger tracks, by way of a cut-off in Queens County, will connect with the Pennsylvania Railroad tunnels and its central station at Thirty-third St. and Seventh Ave., Manhattan, and the Long Island Railroad and its seashore resorts and city stations, and all of these lines with the New York, New Haven & Hartford, and other New England lines. The freight tracks will run across Queens and with the Long Island Railroad will form a big loop



Main Span of the Hell-Gate Bridge of the New York Connecting Railroad of the Pennsylvania System.

per cent. of old cribwork and a little rock. Some of the boulders lifted by the dredge weighed 10 to 15 tons. Perhaps the best month's work done was the removal of 25,600 cu. yd. of old cribwork composed of timber and stone. Larger amounts of material were removed in other months, but the work was not of such a difficult character. A very successful card system has been used in recording in detail the daily operations of the dredge and the towing company's tugs.

The "Independent" was designed by Mr. W. H. Arnold, M. Am. Soc. C.E., chief engineer of the Bush Terminal Co., the engineers of the Lidgerwood Mfg. Co. co-operating in the detail designing of some features. All the operating machinery was made by the Lidgerwood Mfg. Co., except the boiler, which was made by the Heipershausen Bros., New York, and the pumps, which were supplied by the W. H. Blake Steam Pump Co.

WATER SOFTENING is affected in the case of the London supply by storage, according to Dr. T. E. Thorpe, who has reported on the character of the water for many years to the Local Government Board. The hardness of the supplies drawn from the Thames River varies from 20 to 23 parts per 100,000, and has caused considerable comment. Since the construction of the Staines reservoir, described in The Engineering Record of Nov. 28, 1903, the hardness in the supply from this storage furnished by one of the works was reduced about 20 per cent. An unusual incident still further emphasizes the effect of the storage in diminishing hardness. Late in December, 1906, the Hanworth works of one of the London plants began to utilize water from new reservoirs, which had been filled a long time before with water from the Staines reservoir. This water had been filtered and returned to storage several times during pumping trial and contained only half as much carbonate as the ordinary filtered water.

the promise of the improvements contemplated by the Pennsylvania R. R. and by the Hell Gate bridge. The completion of this road is obviously the key to the development of the commercial and manufacturing traffic in Brooklyn and Queens. The road will be joined by a short direct line with the Manhattan tunnel line, thus permitting a new and direct all-rail communication with New England and the north for Manhattan as well as for Queens and Brooklyn. Plans for the bridge were submitted last week by Mr. Samuel Rea, vice-president of the company, to the Municipal Art Commission for its approval, in accordance with the terms of the franchise granted by the city to the company.

This bridge will form part of a steel viaduct, more than three miles long, connecting the New York, New Haven & Hartford Railroad system in the Bronx with the Long Island and the Pennsylvania Railroads. With a sweeping curve the viaduct will pass over Hell Gate, Ward's Island, Little Hell Gate, Randall's Island and Bronx Kills. Eighty thousand tons of steel will be used in its construction. It will carry four railroad tracks on stone ballast so as to render the structure noiseless.

The plans for the bridge show a steel arch of 1,000 ft. span between abutments. These abutments are monumental stone towers, dividing the arch bridge proper from the steel viaduct that forms approaches to it. Granite at the base and moulded concrete above, the towers will rise to a height of 200 ft., and will contain rooms needed for railroad operation. The tracks themselves will be 140 ft. above the water, passing through the steel arches that rise 130 ft. higher. Some of the steel members will be 9 ft. in maximum diameter and weigh 100 tons each.

Besides planning a bridge of ample strength the company has endeavored to make it a thing of beauty. Mr. Gustav Lindenthal designed the

around Brooklyn. Through freight from New England to the South and West will be carried over this route and across New York Bay from Bay Ridge to Greenville, N. J. Thus there will be two distinct routes for the two classes of traffic, and neither will interfere with the other.

SEWAGE DISPOSAL WORKS consisting of septic tanks and percolating filters have recently been opened at Macclesfield, England, in place of the chemical precipitation system formerly employed. The tanks used for precipitation have been enlarged and others built, so that the total tank capacity is now equal to the dry-weather flow for one day. The septic sewage passes from them to four percolating filters, each 120 ft. in diameter and of $6\frac{1}{2}$ ft. average depth. These filters have concrete floors somewhat inclined from the center toward the circumference for drainage purposes, and their walls are constructed of brick reinforced by four $2\frac{1}{2}$ -in. steel bands. Headers have been omitted in the wall at frequent intervals for aeration purposes, and the openings at the floor level left in this way also served for drainage. Broken stone is used for the filtering material. The septic sewage is distributed over each filter by four revolving arms pivoted at a center pier and arranged to be driven by the head of the sewage as it reaches them or by an electric motor. The effluent from these filters is conducted to a secondary filter, 408 ft. long and 107 ft. wide, which consists of 1 ft. 9 in. of broken clinker with a surface layer of fine pottery saggars. The effluent from the percolating filters is distributed over this bed by means of half-pipe channels on its surface and is drained from it through perforated pipe in the bottom. If so desired the effluent from the secondary filter can be run over a tract of land, but ordinarily it will be discharged directly into a neighboring river.

Experiences with Superheated Steam.

A paper presented at the Indianapolis convention of the American Society of Mechanical Engineers by Geo. H. Barrus.

Plant A.—My experiences with superheated steam date back to 1874, and they began at the Massachusetts Institute of Technology in connection with the "Dixwell" experiments. The plant on which these experiments were made consisted of an ordinary 36-in. vertical fire-box boiler set in brickwork and provided with a Dutch oven furnace, a rectangular cast-iron superheater set over an independent furnace, and an 8x24-in. non-condensing Corliss engine.

proved to be a most satisfactory form of superheater. With it there was no difficulty in maintaining a temperature of 600° F., and superheating all the steam that was required by the 8x24-in. engine.

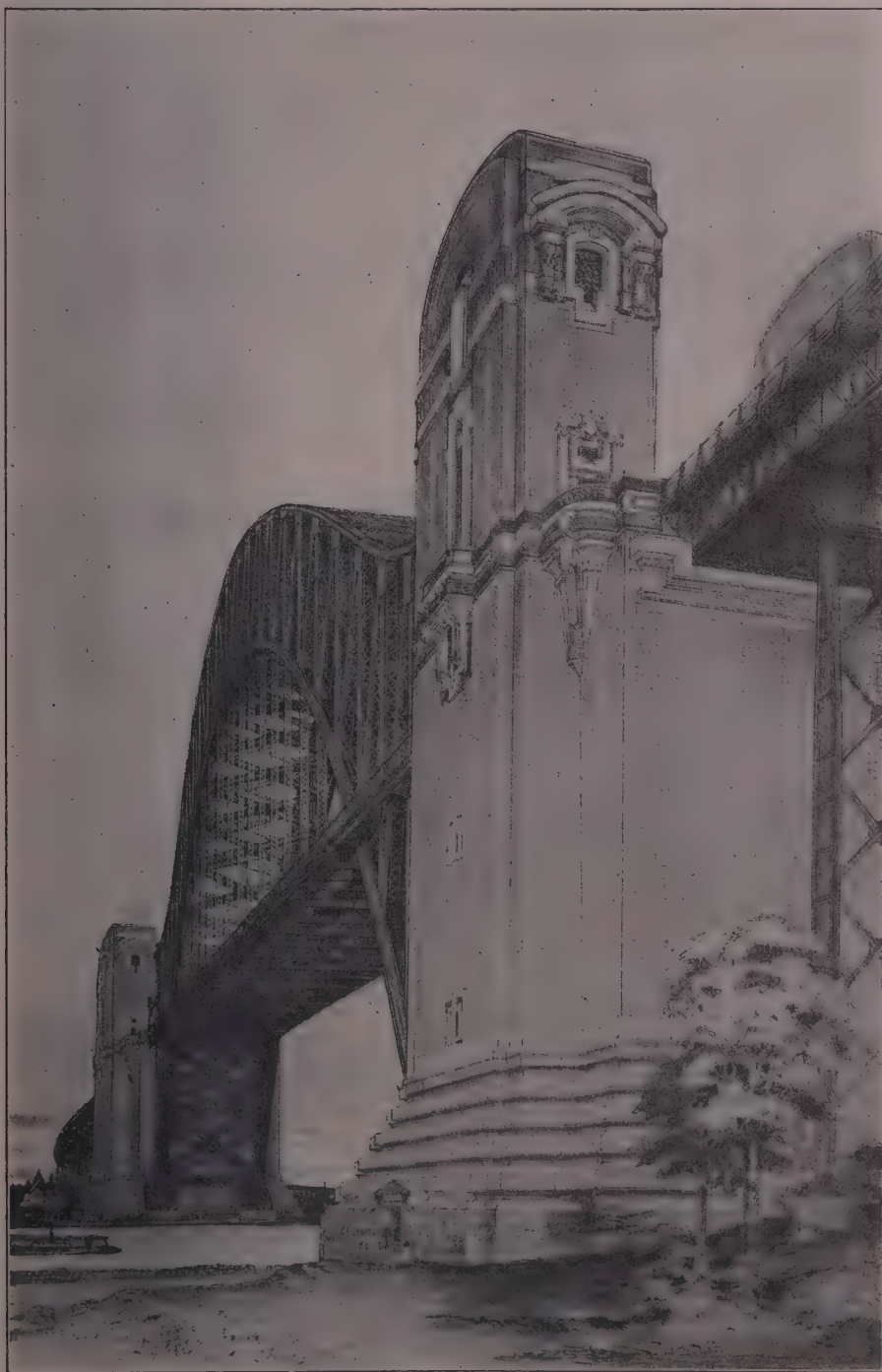
The object of the Dixwell experiments was to show that the degree of superheating necessary to prevent cylinder condensation varied in direct proportion to the ratio of expansion. On the engine in question, with a ratio of expansion of 3 to 2, the number of degrees required was about 110; with a ratio of $2\frac{1}{2}$ to 1, the number was increased to 146°, and with a ratio of 4 to 1, it was still further increased to 190°. As a telltale, indicating when the condensation in the cylinder

important feature of the work. When the engine was running with ordinary saturated steam, the pyrometer responded to the variations of temperature in the cylinder, and during every revolution the index hand vibrated over a range of 20° to 25° of temperature. It jumped to the highest point at the beginning of the stroke when the steam was admitted, and then fell off to the lowest point during expansion and exhaust. When the steam began to be superheated, the range of vibration began to diminish, and when the temperature rose to a sufficient degree, the vibrations disappeared altogether, and the pyrometer indicated a constant temperature. The latter was slightly above the normal for the initial pressure. It is thus seen that with the 4 to 1 ratio of expansion and 190° superheat at the throttle valve, there was a very large drop in temperature in the short distance between the throttle valve and the interior of the cylinder, that distance being not more than two linear feet.

In connection with this work an interesting experiment was made to demonstrate to what extent the drop in temperature between the throttle valve and the cylinder was due to heat converted into work. The engine was stopped and the four valves set wide open. Then the throttle valve was adjusted to such an opening as to discharge steam at the same rate as was consumed when the engine was running. With a ratio of expansion of $2\frac{1}{2}$ to 1 and a temperature of 450° at the throttle valve, the cylinder temperature was 70° lower and the exhaust pipe temperature 140° lower when the engine was running than when the steam was blowing through. In another case with a ratio of 3 to 2 and 410° temperature at the throttle, the cylinder temperature was 45° lower and the exhaust temperature 120° lower with the engine running than with the steam blowing through. A comparatively small portion of the drop in temperature was therefore due to radiation losses, and a large portion to the conversion of heat into work.

Plant B.—The next experience was with a superheater of the Bulkley type, set over an independent furnace, and surmounted by a coil of wrought-iron pipes. The area of exterior surface in the main superheater, which consisted of two U sections, was some 60 sq. ft., and that in the added pipes about 60 ft. more, making a total of about 120 sq. ft. The area of grate surface was 7 sq. ft. This apparatus readily heated the steam made by an 80-h.-p. boiler, which was 75 ft. away, to any temperature desired. On a test it was found that one pound of anthracite coal, containing 15 per cent. of ash and refuse, superheated 50 lbs. of steam 228°, besides evaporating the moisture due to condensation in the steam pipe, and whatever moisture came over from the boiler. The steam pressure was 75 lb.

Plant C.—Another experience with a superheater of the Bulkley type was a case where the attachment was made to a horizontal return tubular boiler. The boiler was one of a plant of two, the shells of which were 48 in. in diameter and 16 ft. long, used in running a 16x36-in. non-condensing four-valve engine. In this engine the steam valves were of the double poppet type, and the exhaust valves, plain slide valves. All the steam passed through the superheater. A test was made before and after the installation. The consumption of small anthracite coal before the application was 4.4 lb. per indicated horse-power per hour. When the superheater was applied the temperature was raised 66° and the coal consumption was reduced to 4.1 lb. per indicated horse-power, the saving being about 6 per cent. The superheating in this case was not sufficient to wholly prevent condensation. A cylinder pyrometer which showed a vibration of 48° with saturated steam still gave 22° with the limited superheating.



Architectural Treatment of Main Piers, Hell-Gate Bridge.

The superheater here proved unreliable. It cracked after a short time, and was abandoned. Later the vertical boiler was found to answer every purpose by simply carrying the water to a low point, and exposing considerable steam heating surface to the action of the products of combustion. The temperature of the steam was regulated by the activity of the fire. This apparatus

was suppressed, a cylinder pyrometer, which was similar in outward appearance to any metallic pyrometer, was inserted through the wall of the cylinder in such a position as to lie diametrically across the cylinder just beyond the counter-bore, and a cavity was cut in the inside face of the cylinder head to make room for it. The action of this instrument proved an interesting and

The superheater in this case was located behind the bridge wall in the manner usually followed for this type of boiler, and the only heat to which it was exposed was that radiated downward from the products of combustion passing under the boiler shell. With a view to increasing the degree of superheating, an independent furnace was built under the superheating pipes, having fire and ash doors placed in the side wall. The grate had an area of 7 sq. ft. By burning $5\frac{1}{2}$ lb. of coal per square foot of grate per hour the superheating was increased to 165° , and the vibrations of the pyrometer were reduced to 17° . Under these circumstances a test with the superheater shut off gave a consumption of 4.21 lb. of small anthracite coal per indicated horse-power per hour, and with the superheater running under the conditions noted, 4.04 lb., the saving was 4 per cent. The decrease in evaporation per pound of coal due to the superheater was 10.2 per cent.

Plant D.—Still another experience was with a Bulkley superheater, this one being arranged in three sections, and set in an independent furnace. The heating surface was about 90 sq. ft. and, the grate surface about 6 sq. ft. It was arranged for superheating the steam used by a 21 and 42x48-in. compound Wolff engine. This engine had slide valves for initial steam and final exhaust, and cylindrical valves, similar to the Corliss, for the exhaust of the high-pressure cylinder, which served also as the admission valves of the low-pressure cylinder. The vacuum was produced by an independent steam-driven air pump and condenser 12x16x18 in. The superheater was placed near the engine. The boilers, which were 250 ft. away, were of the horizontal return tubular type. No provision was made for draining the steam pipe, and all the water condensed in the pipe, or brought over from the boilers, was re-evaporated by the superheater.

The plant ran $10\frac{3}{4}$ hours per day, and, at the end of the day, the fires in both the boilers and superheater were allowed to burn out, being started again with wood in the morning. A test was made using anthracite coal, broken size. The engine developed 425 i.h.-p. and used about 8,700 lb. of feed water per hour, or 20.5 lb. per indicated horse-power per hour. The coal used in the superheater for the day's run of $10\frac{3}{4}$ hours was 277 lb., or only 2 per cent. as much as the coal used in the boilers. This amounted to 13,815 lb. and the total coal was at the rate of 3.02 lb. per indicated horse-power per hour. It was found that the temperature of the steam coming out of the superheater was no greater than that going into it; in fact, it was a little less, showing that the only benefit derived was the re-evaporation of the water contained in the steam.

Plant E.—The next experience was with superheated steam generated by vertical tubular boilers of the Corliss rolling-pin type. Two of these were used for supplying a 23x60-in. single-cylinder Corliss non-condensing engine. The area of grate surface in each was 45 sq. ft.; water heating surface in each, 940 sq. ft., and steam heating surface, 425 sq. ft.; 90° of superheat were produced with a flue temperature of 480° and a rate of combustion of 11 lb. of anthracite broken coal per square foot of grate per hour. A test of the engine was made when using steam derived partly from the two boilers mentioned, and partly from a horizontal return tubular boiler producing saturated steam, the vertical boilers doing so much of the work, however, that the steam was still superheated 82° . The consumption of feed water was 26.8 lb. per indicated horse-power per hour. When the horizontal boiler was crowded to supply most of the steam, and the vertical boilers supplied so little that the superheating disappeared, the consumption of feed water was increased to 29.3 lb. per indicated horse-power per hour. The difference in these figures is about 9 per cent. The difference

in the evaporative performance of the boilers was so much greater in favor of the horizontal boiler that the consumption of coal was in both cases about the same.

In this connection it may be added that, in the case of four other simple engines which the writer tested, where the amount of superheating ranged from 25° to 59° , with an average of 34° , there was a reduction in the percentage of cylinder condensation and leakage, as compared with that found in engines using ordinary steam under similar conditions, amounting to 8 per cent.

Plant F.—The next experience was with a plant of five 64-in. vertical boilers of the Corliss "Centennial" type, having 3-in. tubes 14 ft. in length, each boiler having 951 sq. ft. of heating surface, of which 317 sq. ft. was steam-heating surface. These boilers superheated the steam 75° . They supplied a 28x48-in. single-cylinder non-condensing Corliss engine through a 12-in. pipe 270 ft. in length. The drop in temperature between the boilers and the throttle valve when the engine indicated 410 h.-p. was 49° , so that at the engine the superheating was only 26° .

The chief interest in this plant lay in the effect of the hot steam and hot gases on the long fire tubes. It was found on a feed water test of the plant that the engine consumed 31 lb. of steam per indicated horse-power per hour, and on a leakage test the output of the boilers appeared to be at the rate of about 1,500 lb. of steam per hour, or nearly 4 lb. of steam per indicated horse-power per hour. The leakage was traced to the upper tube sheets where a large number of the tube ends were blowing steam. Re-rolling of these tubes overcame the leakage to a considerable extent, but did not altogether prevent it.

In the other vertical boilers which have been referred to, where there was an equal amount of superheating without difficulty of this kind, the length of tubes was 10 ft. or less, and they were of smaller diameter.

Plant G.—The next experience was with an independently fired superheater of somewhat larger proportions than any thus far referred to. The heating surface here was made up of 2-in. continuous wrought-iron pipes which presented a total area of 2,640 sq. ft., and the grate surface measured 32 sq. ft. The brick setting measured 16 ft. long, 9.5 ft. wide and 22.5 ft. high, over all. Steam was supplied from a plant of Babcock & Wilcox horizontal water-tube boilers containing 10,500 sq. ft. of heating surface and 178 sq. ft. of grate surface.

A ten-hour test was made with this superheater delivering steam at a temperature of 697° F. The boiler pressure was 149 lb., giving a superheating of 337° F. The weight of steam passed through was 25,982 lb. per hour. The weight of dry coal consumed was 535 lb. per hour, and this had 8 per cent. ash and refuse. The calorific value of the fuel was 15,271 B.t.u. per pound of combustible. Reducing these quantities to the unit rate, one pound of dry coal superheated 49 lb. of steam 337° besides evaporating whatever moisture was carried over from the boilers and condensed in the connecting pipes. It is probable that the percentage of moisture, all told, which entered with the steam was between 1 and 2 per cent.

A noteworthy incident of this test was the effect of the highly heated steam on the joints of the piping and on the packings and gaskets of the valves. Whenever the steam came in contact with the fibrous material or rubber, these were completely burned out, and the joints or valve stems set to profuse leaking. The flange joints in the piping, which were of the Van Stone type with corrugated copper gaskets, were injured to some extent and many of them set to leaking. The plant had previously been run at a temperature not over 550° . Under this temperature there was no leaking at any point.

Plant H.—Another case of an independent superheater similar to that of the preceding plant is of interest. This was one which was used in a factory running ten hours per day, and during the remaining fourteen hours the superheater was out of active service, and the fire was banked. This superheater had 1,810 sq. ft. of heating surface and 32 sq. ft. of grate surface. The boilers were of the horizontal water-tube type.

A test was made covering the entire working period of twenty-four hours, and under the regular working conditions. The weight of dry New River coal consumed in the superheater was 3,092 lb. and it contained 7.9 per cent. of ash and refuse. The weight of water evaporated and passing through the superheater was 152,114 lb. The number of degrees of superheating during the ten hours' running time averaged 303° , and the pressure was 136 lb. The boiler horse-power developed during running time was 389. Reducing these figures to the unit rate, one pound of dry coal superheated 49 lb. of steam 303° , besides evaporating the moisture in the steam supplied by the boilers. The steam probably contained 1 per cent. of moisture.

A Corliss compound condensing engine to which the steam from this superheater was supplied was found to consume 9.8 lb. of steam per indicated horse-power per hour when the superheating at the throttle valve was 300° .

Plant I.—I will refer finally to a case of superheated steam furnished by a combined water-tube boiler and superheater, embracing comparative tests between such a boiler and a straight boiler of the same size and type. The grate surface was of the same area in both. The heating surface in the straight boiler had an area of 2,797 sq. ft. and this was all water heating surface. In the superheating boiler the water heating surface was 2,571 sq. ft. and the steam heating surface 595 sq. ft. Total, 3,166 sq. ft.

The tests were made with semi-bituminous coal at, or near, the rated capacity of the respective boilers. The steam from the straight boiler contained 3/10 of 1 per cent. of moisture. That from the superheating boiler was superheated 216° , with a pressure of 145 lb.

Making allowance for the heat represented by the superheating on the assumption that the specific heat is 0.48, the efficiency of the two outfits came out precisely the same, viz.: 75 per cent. of the calorific value of the fuel.

THE EFFECT OF WATER used in making concrete aroused an animated discussion among German concrete specialists in 1901, and to settle it about 99 tons of test pieces were made up by various parties and sent to Prof. C. Bach, of Stuttgart, for test. This work lasted about four years and the results have recently been published in the "Zeitschrift" of the Society of German Engineers. The records of the methods of preparing the test pieces and the amounts of water used in mixing the materials were forwarded with the samples. Tests of samples made by the same men under uniform conditions in Prof. Bach's laboratory, showed that the smallest amount of water which produced a mixture suitable for ramming gave the strongest concrete, but the highest degree of skill and care was required. Larger amounts of water enabled less competent workmen to produce good concrete and in practical work are an insurance against the injurious effects of varying degrees of moisture in the sand and stone, changeable atmospheric conditions and other factors. These statements, it will be observed, are the same as those made by concrete specialists in the United States and indicate the extreme care necessary in basing field methods on the results of laboratory experiments by trained workmen. The tests represented work done under a great variety of conditions and the specimens were representative of good German practice.

The Great Falls Station of the Southern Power Co.—III.

By Curtis A. Mees and John H. Roddey.

Transmission Lines.—The transmission system of which the existing lines of the Catawba Power Co. form a nucleus will eventually cover a territory lying in the very heart of the flourishing cotton industry of the Southland.

At present current is transmitted from the Catawba station to near-by towns at 11,000 volts. The poles in use are of juniper, cypress and chestnut, 35 ft. long, 14-in. butt and 7-in. top. The butts are liberally coated with coal tar and are buried in the ground to a depth of $5\frac{1}{2}$ ft. The cross arms are of long leaf yellow pine painted two coats, the pins being boiled in paraffine. The Rock Hill line consists of two circuits of No. 1-0 hard-drawn copper wire on Nos. 1 and 2 Imperial insulators used indiscriminately. On the Charlotte and Fort Mill lines Thomas No. 6 T insulators are in use. From the junction point of the Charlotte and Fort Mill lines to Charlotte an aluminum cable of 208,000 c.m. is used, the poles being spaced 150 ft. apart, the usual spacing for copper lines being 100 ft.

The whole transmission system, with the exception of the Rock Hill, Fort Mill and Yorkville lines, is being changed preparatory to transmitting at 44,000 volts, immediately upon the completion of the Great Falls station. From Great Falls to Catawba station a trunk line supported on steel towers is being built. At Catawba station a transformer house is being erected, containing three 2,000-kw., 11,000-44,000-volt transformers with suitable switching apparatus for running the two stations in multiple.

Both primaries and secondaries of transformers throughout the whole system are delta-connected. By this arrangement the line voltage may be raised should a higher voltage be deemed advisable in the future.

cables form approximately an equilateral triangle, whose sides are 6 ft. in length, two of them being supported on a cross arm and one on a special cast iron bracket, which fits snugly over the top of the pole. Thomas No. 3020 insulators 13 in. high and 12 in. across the top and Locke No. 334 insulators, 12x12 in., are used indiscriminately. With a view to meeting general adaptability a

pine $4\frac{3}{4}$ in. x $5\frac{3}{4}$ in. x 7 ft. long dipped for 15 min. in carbolineum avenarius at a temperature of 65° C. The increasing weight of the cross arm after having been subject to the above treatment is about $4\frac{1}{2}$ per cent.

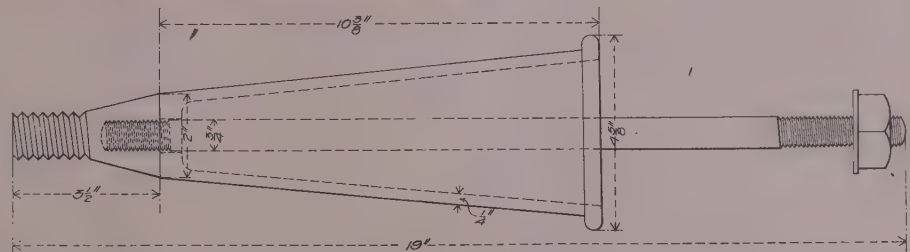
The lightning wire is supported by a $2\frac{1}{2}$ -in. galvanized pipe flattened at each end. The pipe is fastened to the pole and the cast-iron bracket. This ground is $9/32$ -in. diameter stranded iron cable and is fastened by a $\frac{1}{2}$ -in. U bolt to the supporting pipe, which is grounded at each pole through a No. 8 galvanized-iron wire to a 12x12-in. galvanized plate, the connecting wire being fastened to the pole by means of staples placed at suitable intervals. A metallic return telephone circuit is carried on a $2\frac{3}{4}$ x $3\frac{3}{4}$ -in. cross arm placed 7 ft. below the line, the insulators supporting this being Thomas No. 1013, good for 10,000 volts. This circuit is also used for telegraphing in case the telephones are out of commission.

Each 44,000-volt insulator was tested at the factory by a representative of the Southern Power Co. and stood the following tests: First, each separate part stood 50,000 volts; second, the built-up insulator stood a dry test of 120,000 volts; third, the built-up insulator stood an e.m.f. of 88,000 volts for five minutes with a precipitation of $1\frac{1}{4}$ in., the water being delivered under a pressure of 50 lb. per square inch from a sprinkler nozzle and at 30° to the horizontal.

In the diagrammatic layout of the transmission system all solid lines are either in operation or



Towers of Transmission Line.



Pin for Insulator, Comprising Pin Bolt, Pin Stem and Pin Head.

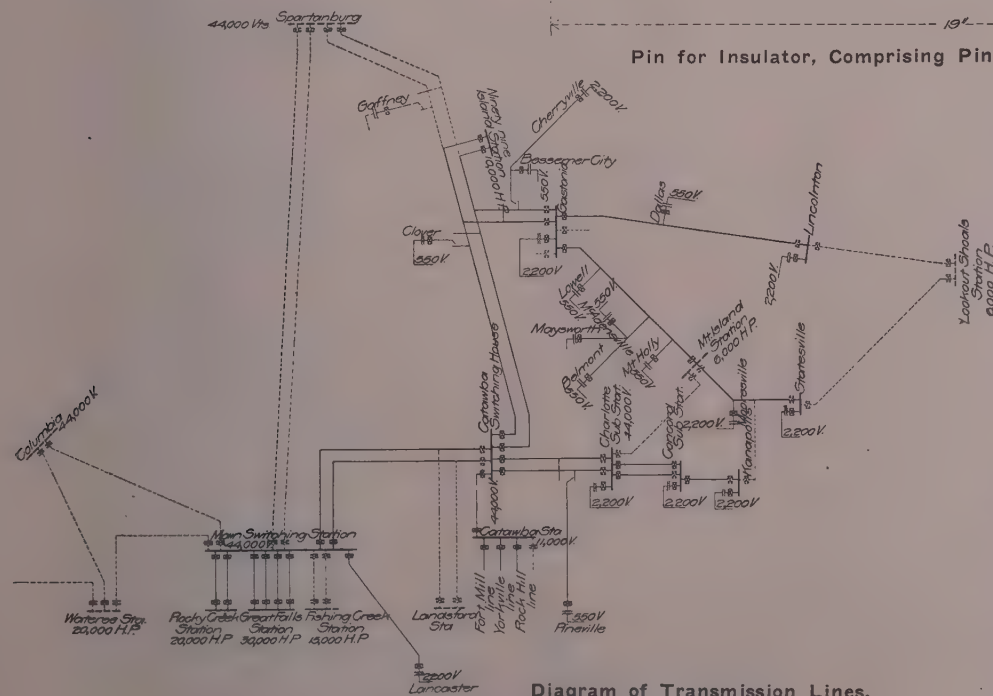


Diagram of Transmission Lines.

Temporarily, at least, the Catawba station will be the distributing point of this system. With exceptions noted above, the lines emanating from this station will be operated at 44,000 volts; of these there will be two—one to Gastonia and the other through Charlotte to Concord, N. C. Each of these lines will consist of two single-circuit wooden pole lines located side by side. A 35-ft. cypress pole is used to support each circuit of No. 2-0 six-strand hemp core cable. The three

special insulator pin was designed. This consists essentially of a cast-iron sleeve through which passes a $\frac{3}{4}$ -in. bolt. A cast-iron bushing is cemented into the insulator and into this bushing the through bolt is screwed. By the use of such a pin strength is assured and in broken insulators the bushing only is lost, while for whatever support it may be desired to use them on it is necessary merely to use a bolt of greater or lesser length. The cross arms are of long leaf yellow

under construction. The dotted lines indicate future installations.

Towers.—The transmission scheme contemplates the eventual construction of a circuit trunk line into which all power stations shall feed, and on this circuit, at least, galvanized-steel towers are to be used throughout. These towers are designed for two circuits, each circuit having a ground wire placed above the highest transmission wire in such position that a line drawn through this ground wire and the upper transmission wire forms an angle of 60° with the horizontal.

A six-strand cable with hemp core, the equivalent of No. 3-0 wire is used for the main conductor, and a solid iron wire is used for the ground conductor. The transmission wires are located at the corners of an equilateral triangle, the sides of which are 6 ft. in length. The towers also support a telephone line strung 27 ft. above the ground and passing through the center of the tower. The spacing of towers is approximately 420 ft., the average number per mile being twelve. Where the ground is moderately level a standard tower 35 ft. in height from the ground line to the lowest conductor is used, while for very uneven ground there have been provided two special height towers of 43 ft. and 50 ft., respectively. The 35-ft., 40-ft. and 50-ft. towers weigh 2,400, 3,000 and 3,500 lb., respectively, and are all of the same type of construction.

These are essentially twin towers, each half being joined to the other at a point midway between the base and the top of the tower proper. The $3\times3\times3/16$ -in. corner angles of each half, as

viewed from a point normal to the line, form A frames, and are clamped together at a point $2\frac{1}{2}$ ft. above the highest cross arms, while the two other main members, $3\times 3\times \frac{3}{8}$ in., of half of the tower, as viewed from the same point, form A frames at one-half the height of the tower and are riveted together. To these members is riveted a $3\times 3\times \frac{3}{16}$ -in. third member, which is clamped to the corner angle at the top.

Each half of the tower, therefore, has four main members from the ground to a point equal to one-half of the height and from this point up only three.

As viewed in the direction of the line the corner angles are upright with diagonals from the apex and from the base to the center of the tower. All main members are securely held together by means of tie rods and angle iron struts. The two halves of the tower are joined together with a batten plate. The width of the base in the direction of the line is 13 ft. 2 in., while in the opposite direction it is 14 ft. 6 in.

For each conductor there is provided a separate cross arm consisting of two $2\frac{1}{2}\times 2\frac{1}{2}\times \frac{3}{8}$ -in. angles placed back to back, the pin end of each cross arm being braced to the tower by a 2-in. pipe. The insulator pins are made of standard 2-in. pipe drawn down at the top and threaded to take firm hold in the top of the insulator, into which they are cemented. A 3020 Thomas insulator with a special bottom petticoat is used. This insulator is 13 in. high, having a cap 12 in. in diameter.

The four legs of the tower are each bolted to an angle-iron foot, the foot consisting of two $3\times 3\times \frac{3}{8}$ -in. angles placed back to back and fastened to the upright angle, to which the main member of the tower is bolted. The foundation for each foot is of concrete, the rock for same being found along the right of way. Each foot is placed in a hole 2 ft. 6 in. in diameter and 5 ft. 6 in. deep, the hole being then filled with concrete. On account of the design of the foot the mass of concrete is shaped something like a boot, the cross angles being imbedded in the foot of the boot.

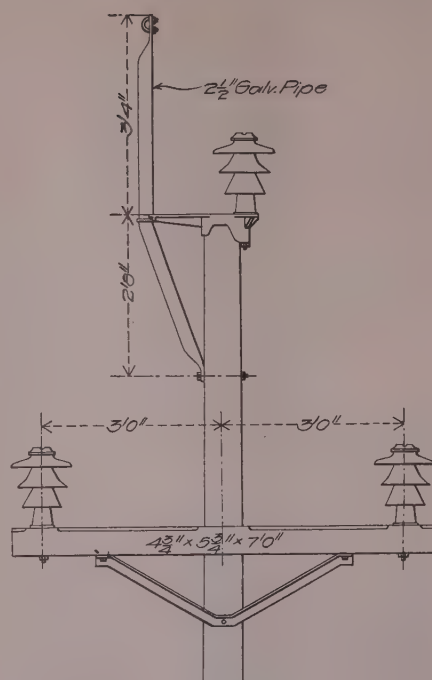
A special interchangeable tower has been designed for turning angles, making transposition, sectionalizing the lines and for tapping off branch lines. One or more 12x12-ft. towers 35 ft. in height are used, depending upon the requirements of the problem. Each 12x12x35-ft. unit tower weighs approximately 8,000 lb.

When used for turning angles, one tower is placed a width ahead of the other, and the two adjacent corners are bolted together. For tapping off to branch lines one tower only is used, the main conductors passing over the top of the tower and tapping down to the branch line, which is provided with a set of selector switches.

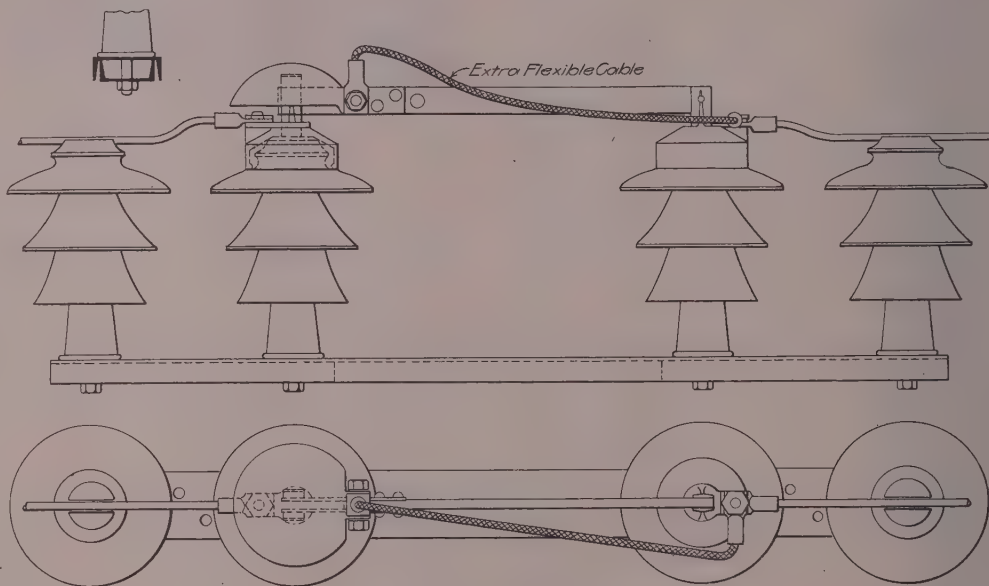
The line is suitably transposed and is sectionalized at each point of partial transposition.

This combination of connections requires the use of four of the 12x12-ft. towers with a special insulator flange bolted between the two pairs of towers. Five sets of selector switches are so arranged that a crossover from one circuit to the other may be effected and any section may be cut out for repairs in case of a breakdown. For outside work a special disconnecting switch has been designed, the insulators of which are mounted on a 5-in., $6\frac{1}{2}$ -lb. channel and in place of the customarily used copper bar a steel bar is used. This has a copper contact and the circuit is made through a flexible cable. These special towers were furnished by the U. S. Wind Engine & Pump Co., of Batavia, Ill.

The standard 35-ft. tower stood the following tests: First, a horizontal pull of 1,000 lb. applied at the top of each insulator pin and the ground wire supports showed no appreciable deformation. Loads were applied both in the direction of the



Pole-Top, 44,000-Volt Line.



Line Disconnecting Switch.

line and at right angles thereto. Second, a horizontal pull of 8,000 lb. applied across the two apices of the tower both in the direction of the line and at right angles thereto showed no noticeable deformation. Third, when tested to destruction the tower collapsed at a corrected pull of 14,000 lb. applied across the apices of the tower in the direction of the line.

The standard towers were furnished by the Aero-motor Co., of Chicago, the transmission wire by John A. Roebling Sons' Co., of New York, and the insulators by the Western Electric Co.

Construction Plant.—The construction plant used in this work consisted essentially of the following: Thirteen guy derricks equipped with bull wheels, six of which had masts 100 to 110 ft. high, and all built from sticks selected on the property; four guy derricks without bull wheels; two stiff-leg derricks with bull wheels; ten Lidgerwood hoisting engines with double $8\frac{1}{4}\times 10$ -in. cylinders, double friction drums and swinging-gear attachments; one Lidgerwood hoisting engine without swinging gear; one Lidgerwood engine only; five Lambert hoisting engines equipped with patented swinging gear; twelve stationary boilers varying from 20 to 90 h.p.; six engines of various capacities for crushers, machine shop,

etc.; one 50-ton locomotive; one 10x16-in. saddle tank locomotive; one Manhattan elevated locomotive; one 7x12-in. saddle tank locomotive; three other dinkeys; one $2\frac{1}{4}$ -yd. Marion steam shovel; one $1\frac{1}{4}$ -yd. Little Giant steam shovel; one No. 5 Austin gyratory crusher; two No. 4 Champion rock crushers; six flat cars; nine Austin dump cars; sixteen other side dump cars; four $1\frac{1}{4}$ -yd. end dump cars for concrete mixtures; two 1-yd. orange-peel buckets; eighteen buckets from $1\frac{1}{2}$ to $2\frac{1}{2}$ -yds., with wooden and steel skips; nine duplex pumps of various capacities, several centrifugal pumps, bilge pumps and steam syphons, twelve rock drills, twelve drag scrapers, Wells lights, Holland lights and other small equipment.

There were two concrete mixing plants used, both of which were gravity installations; two No. 4 Smith mixers were used in them.

A machine shop was fitted out with the following large tools: One 18-in., 12-ft. engine lathe; one 28-in. swing drill; one power hack saw; one shear; one bolt cutter; one 250-lb. single-frame steam hammer; four forges in shop, while others were used at all points convenient for steel sharpeners.

There was also used an 8x8-in. Ingersoll-Rand air compressor, with riveting and chipping hammers, calking tools and air drills. This com-

pressor was later permanently located in the power house.

Construction work was carried on under the direct supervision of Mr. W. A. Leland, M.Am. Soc.C.E., as resident engineer. The force employed reached at times 1,000 laborers, while it averaged nearly 600 men working frequently in night and day shifts.

The property holdings for this entire development aggregate nearly 9,500 acres, much of which could not be leased for agricultural purposes, and on such land 750 pecan trees were planted, which in time are expected to bring good returns.

The railroad from the site of the power plant to a connection with the Lancaster & Chester R. R. at Fort Lawn, S. C., was built by Messrs. Stewart & Jones, of Rock Hill, S. C., under contract.

The organization of the Southern Power Co. was effected under a New Jersey charter with an authorized capital of \$7,500,000. Of this amount \$2,500,000 was set aside as preferred stock, yielding 7 per cent. cumulative dividends, the remaining \$5,000,000 being common stock. On Oct. 24, 1906, the capital stock was increased to \$10,000,000, the additional \$2,500,000 being apportioned to the preferred stock. The officers of this company

are: Dr. W. Gill Wylie, of New York, president; B. N. Duke, of New York, first vice-president; W. S. Lee, Jr., M.Am.Soc.C.E., Assoc. A. I. E. E., of Charlotte, N. C., second vice-president and chief engineer; R. B. Arrington, of New York, secretary and treasurer; L. C. Harrison, of Charlotte, assistant secretary; W. H. Martin, Jr., of Charlotte, assistant treasurer. The personnel of the board of directors other than officers is as follows: J. B. Duke, Dr. R. H. Wylie and Junius Parker, New York; Julius Christensen, Philadelphia, and Frank L. Fuller, Durham, N. C.

Recent Progress in the Asphalt Paving Industry.

The development of sheet asphalt pavements has been one of the characteristic features of American municipal engineering. The first piece was laid in a crude way in Newark, N. J., in 1870, and a few short stretches were put down during the next few years in New York. Although not wholly satisfactory they were so promising that in 1876 a large amount was placed under contract in Washington. All the methods of working were empirical, and the necessity of better technical supervision became so apparent that in 1887 Mr. Clifford Richardson was placed in charge of the inspection of the materials and methods by the District authorities. Since then he has been closely identified with the industry, which lends unusual interest to a paper concerning it which he read on May 24 before the New York Section of the Society of Chemical Industry.

Many of the early pavements were very successful, while others were far from being so. Certain percentages of sand, pulverized limestone and asphaltic cement were mixed without any understanding of why these proportions were used, except that the mixture was pleasing to the eye of the person in charge and could be spread upon the street satisfactorily. This was the state of the industry when Mr. Richardson entered it. No attempts to pave streets of more than the most moderate traffic had succeeded, and some disastrous results had been met with.

During the following seven years the problem was studied with very little satisfaction by Mr. Richardson, as the field which was available to him at that time was limited to one city where the conditions were not difficult to meet and the materials available for the mineral aggregate were unfavorable for any attempts at improvement. In 1894, however, the possibility of considering the problem from a broader point of view arose in connection with the construction of pavements in London, England, where the existing conditions and the available materials for a mineral aggregate were quite different from those which had been previously studied. This opportunity, together with a study of pavements which had been more than ordinarily successful and the reverse in a large number of cities in the United States, resulted in the working out a system of construction based upon well-defined principles. In the summer of 1896 these were put in practice and have been largely followed in the industry since that time. A knowledge of these principles is necessary for a comprehension of the advances which have taken place within the last few years.

Briefly, in the construction of the wearing surface of an asphalt pavement, four points must be given consideration, according to Mr. Richardson. Two of these relate to the grading or relation of the size of the particles of sand to each other, one to the amount of finely powdered mineral matter or filler which is present, and the fourth the character and amount of the bituminous cementing material employed to cement and bind together the sand and filler, which together form the mineral aggregate, so called.

In the early days of the industry almost any available sand was used, without regard to its being coarse or fine or of the relation of the coarse to the fine particles. It was subsequently developed that a coarse sand alone did not make a satisfactory surface for several reasons. The voids or spaces between the individual grains are too large, thus permitting the presence of too large masses of bitumen filling these voids and making a surface which marks excessively under traffic or by the stamping of horses with sharply calked shoes. With such sands it is impossible to use a sufficient amount of dust or filler to overcome this, because the sizes of the voids permit of the balling up of the filler while the mixture is hot, so that it cannot be raked and spread satisfactorily on the street. In addition a coarse sand, used alone, makes a surface which is rough and open, from which the particles are readily ground away by traffic, and which is more easily attacked by water.

For these reasons it has been found necessary to have present in the mineral aggregate a certain amount of fine sand, the grains of which are of a size which are retained on a sieve having 200 meshes per lineal inch, and which will pass, some of them, a screen of 100 meshes to the inch, and others, too large to pass the 100-mesh screen, passing an 80-mesh screen. Sand of this character has been found to be one of the most important constituents of the mineral aggregate of an asphalt wearing surface, and without it one of high grade cannot be made, Mr. Richardson states. The reason for this lies in the fact that the small grains fill the voids between the larger ones and give the sand stability by reducing not only the volume of voids, but also that of the individual spaces between the sand grains; that it makes a closer finished surface to the pavement, and because its presence permits the use of the necessary amount of fine dust or filler by preventing its balling up, thus contributing still further to the closeness and density of the mixture and of the finished surface, and preventing the raveling out of the coarser particles of sand under traffic and the disintegration of the pavement by traffic, by displacement, and by weathering.

At the same time it is not found advisable to do away with all the coarser particles of sand, as these have a rôle of their own to play. They must be present to a certain extent to carry the traffic and prevent displacement of the surface, which would be apt to take place if the mineral aggregate consisted only of fine material, as is the case in rock asphalt surfaces, one of the weak points of which is their tendency to push out of shape after continued use.

It has been determined by actual experience that the most desirable grading for the sand to be used in making an asphalt pavement is as follows:

Passing 100 mesh, 17 per cent.	
80 " 17 "	
50 " 30 "	
40 " 13 "	
30 " 10 "	
20 " 8 "	
10 " 5 "	

The presence, as near as may be, according to the sands available locally, of about 34 per cent. of 100-mesh and 80-mesh grains, as equally divided as may be between the two sizes, is regarded as the *first point* to be considered in arranging for the mineral aggregate of an asphalt surface mixture.

The presence of a certain amount of coarse grains, of sizes which are retained on a screen of 40 meshes to the lineal inch, the larger part being of 30-mesh size, less of 20-mesh size, and but a small part of 10-mesh size, to give to the aggregate the necessary stability and to carry the traffic, must be regarded as the *second point* for consideration.

The *third point* is that there shall be present in the mineral aggregate a sufficient amount of impalpable mineral matter which shall pass a 200-mesh sieve, and most of it being finer than 0.05 mm. in diameter, to fill the voids in the sand and give stability to the bitumen present, thus permitting of the use of a softer bitumen as a cementing material than would otherwise be the case. In the higher class of mixtures for streets of heavy traffic, this should reach not less than 13 per cent., being regulated to a certain extent by the presence or absence of finer sand, it being possible to use only a smaller amount when this is absent, owing to the balling of the dust in such a case. It is also regulated to a certain extent by the character of the bitumen which is used as a cementing material, some carrying material acting in itself as a filler, as in the case of Trinidad asphalt, and others being so liquid at the temperatures at which the mixtures are made as to permit of the addition of a larger proportion than can be employed when the bitumen is very viscous at that temperature. The proper use of filler is a very important element in the production of a satisfactory asphalt pavement.

The preceding principles were developed and announced in 1896 and have been confirmed as correct by the experience of ten years under the most trying conditions. Recent developments have been confined to the preparation of fillers of an extremely fine degree of comminution, as it can be readily understood that the finer a filler is, the more satisfactory is its action and the less of it is necessary. Attention may also be directed at this point to the use of Portland cement as a filler. For some reason that cannot be satisfactorily explained, this imparts to a mixture a greater toughness than mere rock powders and a capacity to resist the action of water. It is generally used in surfaces which are to withstand the heaviest travel.

With a proper mineral aggregate assembled, the *fourth point* to be considered is the amount of bitumen or asphaltic cementing material which must be used to bind it together into the most stable and resisting concrete mass and the most suitable consistency for this bitumen.

As far as mere amount is concerned, it will be necessary to have enough to coat each grain and to fill the voids between the grains when the aggregate is compacted to the ultimate extent. This amount will depend on several variables: the character of the surface of the grains of sand, the character of the filler and the viscosity of the bitumen at high temperatures. It has been found by experience that different sands made up of an aggregation of particles of exactly the same size and with the same percentage of voids have different capacities for carrying bitumen, owing to the fact that the film adhering to grains of one kind is much thicker or thinner than that adhering to another having a different surface. For example, a mineral aggregate made with a sand found at Moline, Ill., will carry only 8.5 per cent. of bitumen, where one containing a sand in use at Seattle, Wash., will carry 11.5 per cent. During the last few years an understanding of this peculiarity has done much to aid us in our knowledge of how to produce the most perfect surfaces. In a similar way it has been found that asphalts of different types have very different viscosity when melted, in consequence of which the thickness of the film which the same sand grain will hold varies with different bitumens. On this account, as well as on account of the peculiarities of the surfaces of different sands, the percentage of cementing material which must be used with different standard aggregates will vary. Our knowledge of how to handle such conditions has increased largely in the last few years and the old empiricism has been done away with.

As a rule, the presence of an excess of bitumen

is determined by pressing the hot mixture of mineral aggregate and cementing material at a suitable temperature between Manila paper and striking it several blows. If an excess is present the paper will be strongly stained by the excess which is squeezed out. On the other hand, if there is a deficiency the paper will scarcely be stained at all, and this is sufficient indication that a larger amount of cementing material is necessary. The test demands some experience and good judgment, especially with some bitumens which are very liquid in the melted condition, as in this case a stain may be produced even when insufficient is present.

With a normal sand of standard grading and a suitable amount of filler, about 10.5 per cent. of bitumen as contained in such asphalt cements as are made from Trinidad or Bermudez asphalt is required, but with others which are more viscous as much as 12.0 or even 13.0 is necessary.

If the four points which have been described have been given the necessary attention, the result will be a satisfactory mixture, Mr. Richardson says, for the construction of a lasting pavement, if the bitumen is suitable for the purpose and if it is of proper consistency. The best mixtures will have the following composition:

Bitumen,	10.5 per cent.
Passing 200 mesh, 13.0 "	
" 100 " 13.0 "	
" 80 " 13.0 "	
" 50 " 24.0 "	
" 40 " 11.0 "	
" 30 " 8.0 "	
" 20 " 5.0 "	
" 10 " 3.0 "	

The question of the character of the solid bitumens which are available and of the fluxes which are at hand to soften them was next given consideration by Mr. Richardson. The number of each of these materials which have become of commercial importance during the last few years is much greater than in the early days of the industry, when Trinidad asphalt and the residues from the distillation of Eastern paraffine petroleum were the only sources of supply. Fortunately these bitumens are perfectly miscible, and for many years satisfactory asphalt cement was prepared from them, and later from Bermudez asphalt and the same flux. The flux was not originally prepared for the paving industry, but was a residuum obtained in the distillation of petroleum for the more valuable distillates. Later on, as the importance of the material and sales of it increased, the manufacturers undertook to make it especially for fluxing asphalt, with resulting improvement in its character and uniformity. It has continued to improve in late years owing to the removal of more of the scale paraffine present, which is of course undesirable owing to its susceptibility to temperature changes. It is still used to a large extent where it is suitable. The supply is, however, variable in character from year to year, owing to variation in the sources and character of the petroleum from which it is produced, and skill must be used in determining the effect of such variations.

In the early days of the industry the early eighties, attempts were made to construct asphalt pavements with the very hard bitumens of Cuba and with grahamite. These bitumens could not be fluxed with the paraffine residuums then available, and surfaces made with them were failures. This was owing to a deficiency of malthenes in the asphalt, which the addition of the paraffine oil did not supply. In the nineties the petroleum of California began to be exploited. This oil is made up largely of malthenes such as are found in Trinidad and Bermudez asphalt. At first the heavy natural malthas were proposed and used for fluxes, but these proved very unsatisfactory, as on heating they hardened very rapidly to pitches with the loss of volatile oil, as a consequence of which the paving cement made with it was very changeable in consistency on being main-

tained in a melted condition for any length of time. Later on a much more desirable flux of an asphaltic nature was prepared and is now on the market, made in the same way as the paraffine residuum by removing the lighter portions of the California petroleum by careful distillation. This occupied a conspicuous place in the paving industry as a means of fluxing the hard California asphalts for some years. With its bitumens such as that mined at La Patera, grahamite and gilsonite could be fluxed to a desirable material which could not be handled successfully with paraffine oils. The only difficulty with it was that it was often carelessly prepared, was not uniform, and, owing to high freight rates, was very expensive at any distance from its source.

In 1900, with the coming in of the Spindle Top or Beaumont oil fields in Texas, there was a further addition to the available fluxes for use in the paving industry. This oil was nearly free from paraffine scale and largely asphaltic in nature. The denser portion obtained as a residuum on distillation possessed all of the desirable features of the California flux, but was more desirable on account of its lower density, so that a smaller amount of it would accomplish the same purpose as a larger amount of the heavier flux. It has been much used since that time and has been a valuable material for fluxing asphalts and hard bitumens where paraffine oil cannot be employed. The possibilities which have been brought about by this material must be regarded as one of the most distinct and greatest advances in the asphalt paving industry in the last few years. In fact, with such a flux, it may be said that a certain amount of any stable hard bitumen may be employed in making a satisfactory paving cement. Of course the skill and experience requisite in handling such bitumens is much greater than that which was required in the earlier days of the industry, when Trinidad or Bermudez asphalts and paraffine fluxes alone were in use. Nevertheless good work is done at the present time with combinations of bitumens which it would not have been possible to use some years ago. Our knowledge of the character of the materials of this kind is continually growing and the subject is an interesting one. It is unfortunate that the Beaumont field is practically exhausted and that Texas oils, although still very desirable, are not of as high a grade as formerly.

From the asphaltic petroleum of California and Texas, residual pitches have been prepared by carrying the distillation further than is done in the case of the preparation of the fluxes. These pitches have played some part in the paving industry of late years. They are of very variable character, according to Mr. Richardson, depending on the petroleum from which they are derived and upon the way in which they are manufactured—that is to say, the temperature to which the oil is raised in removing the liquid constituents. This may be carelessly done and the product become much decomposed, in the case of California petroleum the heat rising as high as 1000° F. When the distillation is carefully conducted a product is obtained with which good pavements have been constructed, and it is also of value for mixing with the native asphalts to give them greater fluidity and permit of raking surface mixtures with greater ease and adding a higher percentage of bitumen to the mineral aggregate. The character of the residual pitches—that is to say, whether they have been carefully prepared or otherwise—can be arrived at by determining whether they contain any considerable amount of bitumen which is soluble in carbon disulphide, but not in carbon tetrachloride, the presence of bitumen in this form arising from overheating of the material. If the pitch is made of a consistency only sufficiently hard for immediate use as a paving cement, there is much less danger

of its injury by overheating. Some residual asphalt of this description is now prepared in California for their own use by paving contractors, but none by the distillers of petroleum in that State or from the Texas petroleum.

It has been remarked that greater skill is requisite in working with some bitumens than others. This is a matter of great importance, as the necessary skill is not always available. In such cases it is always well to adhere to the use of the most stable and uniform materials, those which do not suffer from careless treatment. Trinidad asphalt and the paraffine fluxes are the most uniform and stable bitumens from which to make a paving cement, according to Mr. Richardson, since the asphalt is extremely uniform, every cargo from the deposit having exactly the same composition, while it can be subjected to extremely high temperatures without serious injury either by itself or on mixing with sand that is too hot. The flux is equally stable and uniform.

With a surface mixture arranged on the lines which have been described, a lasting pavement surface can be constructed on the street if the form of construction is such as to support it properly and without vibration. In the early days of the industry, represented by the pavement laid on Pennsylvania Ave., Washington, the foundation consisted of 6 in. of natural cement concrete, made in the proportions of one part of cement, two of river sand and between four and five of broken stone. This gave an ample support and is still in use to-day. It possesses some disadvantages, however, being porous and permitting the absorption of ground water, so that it is always wet. This may give rise to a disintegration of the asphalt from the under side as well as from the surface, if the mixture is not a perfect one.

One of the greatest advances in the industry of late years, which has been rendered possible by the enormous development of the Portland cement industry in the United States and the consequent reduction in price of this material, is the construction of the foundation with this more impervious material. Mr. Richardson states that no asphalt pavement can be considered of standard form unless it is supported on a Portland cement concrete base of suitable thickness. In the Borough of Manhattan, New York City, the condition of the asphalted streets to-day, which Mr. Richardson states is not satisfactory, is entirely due, in his opinion, to the fact that they have, as a rule, no proper foundation. There are but two or three streets which have what he considers a suitable base of Portland cement concrete, among them Fifth Ave. and Park Row, while the intermediate course between the foundation and the surface in these streets is such a weak one that he is surprised that the surface has worn as well as it has during its ten years' use on Fifth Ave. Almost all of the sheet asphalt streets of the Borough of Manhattan are laid on old stone pavements, many of them on stone blocks which have been disturbed and turned upon their broader side, thus causing great instability and tendency to vibration in the bituminous surface, which eventually results in its disintegration. This practice originated in the introduction of asphalt pavements into the borough before 1890, when, for motives of economy and because the streets which were paved were those only on which residences abut and of the lightest travel, the old stone pavements were regarded as suitable for foundations. They were so to a certain degree, according to Mr. Richardson, but with the extension of asphalt surfaces to the more heavily traveled streets this practice, for which there was no justification other than economy, was continued, with the result seen to-day.

No stronger contrast, nor one showing more strikingly the difference between asphalt pave-

ments with suitable and unsuitable foundations, can be asked than a comparison of the behavior of pavements of this type in the Boroughs of Manhattan and Brooklyn. In the latter borough a suitable Portland cement concrete foundation has been very generally provided in contrast to the weak bases employed in Manhattan, with results which are very evident. This, too, is more striking when it is known that the asphalt mixtures which have been laid in Brooklyn are not of the high standard that they might be, according to Mr. Richardson. The less satisfactory mixtures have done better in Brooklyn on a well-constructed base than the high-grade mixtures in Manhattan on weak bases, for it is a fact that the greater part of the mixtures which have been laid in the latter borough since 1896 has been the ideal one corresponding in composition to that which has been previously described. Mr. Richardson is astonished that the municipal authorities responsible for the construction of the asphalt pavements in Manhattan do not seem to be alive to the situation in this direction; on the contrary, the results of the use of an inferior base do not seem to have made any impression on them.

With a suitable Portland cement concrete foundation and a wearing surface of the standard type, every provision for a lasting form of asphalt pavement for streets which carry a heavy and continual traffic, such as that supported by Fifth Ave. in New York, which at its busiest hour amounts to more than 14,000 per day of twelve hours, has not been made. It is equally important that the intermediate course between the surface and the foundation should be of rigid construction. This course, as it has been used since 1889, was an inheritance from the old coal-tar pavements of Washington. The base in this pavement consisted of broken stone $2\frac{1}{2}$ -in. in size, coated with tar. The interstices in the surface of such a foundation were necessarily large, and it would not have been economical to use a fine surface mixture of sand and tar directly upon it, as much would have been lost therein. It was the custom, therefore, to apply a course of finer stone of about inch size, coated while hot with melted tar, thus obtaining a surface which was close and sufficiently smooth to permit of applying the surface mixture without great loss. This was known as a binder course.

The earlier asphalt pavements were of a form of construction which provided for the application of the surface mixture directly to the hydraulic concrete foundation. These early mixtures were not prepared on other than an empirical plan and were not stable. With nothing to tie to on the smooth foundation, they were very apt to push out of shape and become very wavy under travel. When, in the year mentioned, it was decided to abandon the laying of coal-tar pavements in Washington, the only change possible under the law, which specified that not more than a certain price should be paid per yard, was that the base and binder courses should remain as in the tar pavements, but that an asphalt surface should be used. This form of construction was found to be so desirable, and to do away so satisfactorily with displacement of the surface under traffic, that it was generally adopted elsewhere and became a permanent feature of asphalt pavements. It served very well for years and does so to-day on streets where the travel is not excessive; but when this form of pavement began to be applied under more trying conditions it failed, and more particularly where the foundation was not a rigid one. The binder under such circumstances, under very heavy loads, such as coal trucks carrying as much as seven tons of coal and similar loads, was either displaced, or crushed if the stone of which it was composed was not an extremely hard rock,

or the surface was forced by the heavy traffic into the voids in the binder course, thus disintegrating the pavement.

One of the greatest improvements in the last few years, but unfortunately one which has been adopted only to a limited extent, has been the change from a binder containing a large volume of voids and consequently very unstable, to an intermediate course composed of the same stone as the old binder, but with the voids completely filled with the fine mixture used for the surface course. With a material of such composition, well cemented with a bituminous cement, a perfectly stable course is obtained between the foundation and the surface, which is capable of sustaining the surface under any travel to which it may be subjected, without the slightest vibration. Naturally it increases the cost of the pavement slightly, but the advantages gained more than make up for this, as a surface thus constructed will have a life increased in amount more than sufficient to bring the cost per year below that of one built on the old lines. It is considered by Mr. Richardson to be the most important advance within the last ten years in the asphalt paving industry, and one which should receive more attention than it has up to the present time. Kansas City and Omaha are the only cities which have up to the present time, as far as Mr. Richardson is aware, approved of such a form of construction, although the desirability of it must be evident even to the layman.

Following the ideas which have been laid down as to the proper methods of constructing the different courses which go to make up an asphalt pavement, Mr. Richardson indicates how they may be combined to make the most satisfactory one under different conditions which may be met. The most difficult problem is that of the street which is to carry the most continuous and heaviest travel. For this purpose a Portland cement concrete at least 6 in. in thickness is necessary, and an even thicker foundation if the sub-soil base is not of the firmest character—that is to say, if the pavement is to be carried over soft ground, a recent fill, or where any particularly unfavorable environment is to be met. Under ordinary circumstances, 6 in. of foundation is enough if it is constructed with a high-grade Portland cement, such as is now readily obtained in the United States, and good hard stone, for which in many instances good gravel may be substituted. Every effort should also be made that proper drainage of the base should be provided to prevent upheaval by frost in northern climates.

Upon such a base 2 in. of close binder, the stone of which should be hard enough to carry the travel without crushing, should be laid as an intermediate course, and on this a wearing surface of standard grading and made with a bituminous cement which consists of a mixture of suitable bitumens, skilfully combined and handled, to the depth of $1\frac{1}{2}$ in. A thicker surface is unnecessary if it is carefully prepared and laid, owing to the rigid character of the support; thicker ones, 2 in., being demanded only on open binder and with poor foundations. Where the travel is light, the old-fashioned and common form of construction may be employed, although it will prove only a momentary economy, and in some residence streets an old stone or brick pavement may be economically and successfully used as a foundation.

In addition to the advances in the technology of the asphalt paving industry and in the form of construction of such pavements, there has been a distinct improvement in the plants which are in use for refining the crude asphalt and in turning out the binder and surface mixtures, which must be sent in a heated condition to the street.

These improvements are largely in the line of economy and uniformity of production and in the type of portable plant which can be moved from place to place with little expense, for work in cities of the smaller size, where the area to be paved does not justify a permanent plant.

At the larger refineries 250 tons of asphalt can be refined or dried in a day, for refining consists practically and almost entirely in the removal of water and the more volatile oils at a temperature of about 325° F. For this purpose the material is not subjected to fire, which might frequently be the cause of overheating it, but is heated by high-pressure steam in coils, and is agitated to accelerate the process by dry steam. In this way a very uniform and perfect product is obtained, none of which has been overheated or coked, and every lot of which can be used in the paving plant in exactly the same way and without varying the proportions of flux or of the asphaltic cement in use in the mixtures.

In place of the permanent plant which in the early days it was necessary to erect wherever a pavement was to be laid, portable plants upon railroad cars are now available, which can be moved to any point where work is to be done, and moved on again to the next point when it is completed. A very successful form recently introduced occupies but one flat car and can be set up and dismantled at small cost. This is a great advance over the two-car plant which was in use for several years, and which was very expensive to put in commission and to take down. The possibility of working in this way has rendered it feasible to undertake a much smaller amount of work in our smaller towns, which would otherwise cost a prohibitive price when done with a permanent plant. The result of all these economies which have been introduced into the industry, on the mechanical side alone, has been that sheet asphalt is now laid at prices very much lower than was the case but a few years ago, while the character of the work is much better, owing to the greater intelligence of those employed in the industry and the more scientific basis upon which it is conducted.

Having outlined the recent advances which have been made in the asphalt paving industry, Mr. Richardson took up the lines of greatest resistance which its further development has to contend against. The pavement has now stood the test of thirty years. More than 50,000,000 yards have been laid, and it is not surprising that in such an area some poor work has been done, even by the best contractors under unfavorable circumstances, and more by those not possessed of the requisite skill or expert supervision. The pavement is no longer a novelty, and the American people dearly love something new and experimental. Competitors constructing other kinds of pavements delight in criticising it and in making comparisons of its merits with those of their own form, which is generally of an experimental nature. Nevertheless it continues to increase in area every year. In 1904, 4,849,731 yards were contracted for in the United States; in 1905, 5,912,357 yards, and in 1906 (to Jan. 31, 1907), 7,241,721 yards. In these three years it was laid in 110 towns of less than 50,000 inhabitants, and in 19 towns of between 50,000 and 100,000 inhabitants, while in 1906 it was introduced into 12 small cities where it had never been laid before. The greatest difficulty which retards the construction of a better form of asphalt pavement to-day is the fact that municipal engineers do not understand the lines on which it is developing, and continue to demand the older form of construction.

TWO TANGENTS, each 22 miles long, are being constructed on the Baton Rouge, Hammond & Eastern Ry.

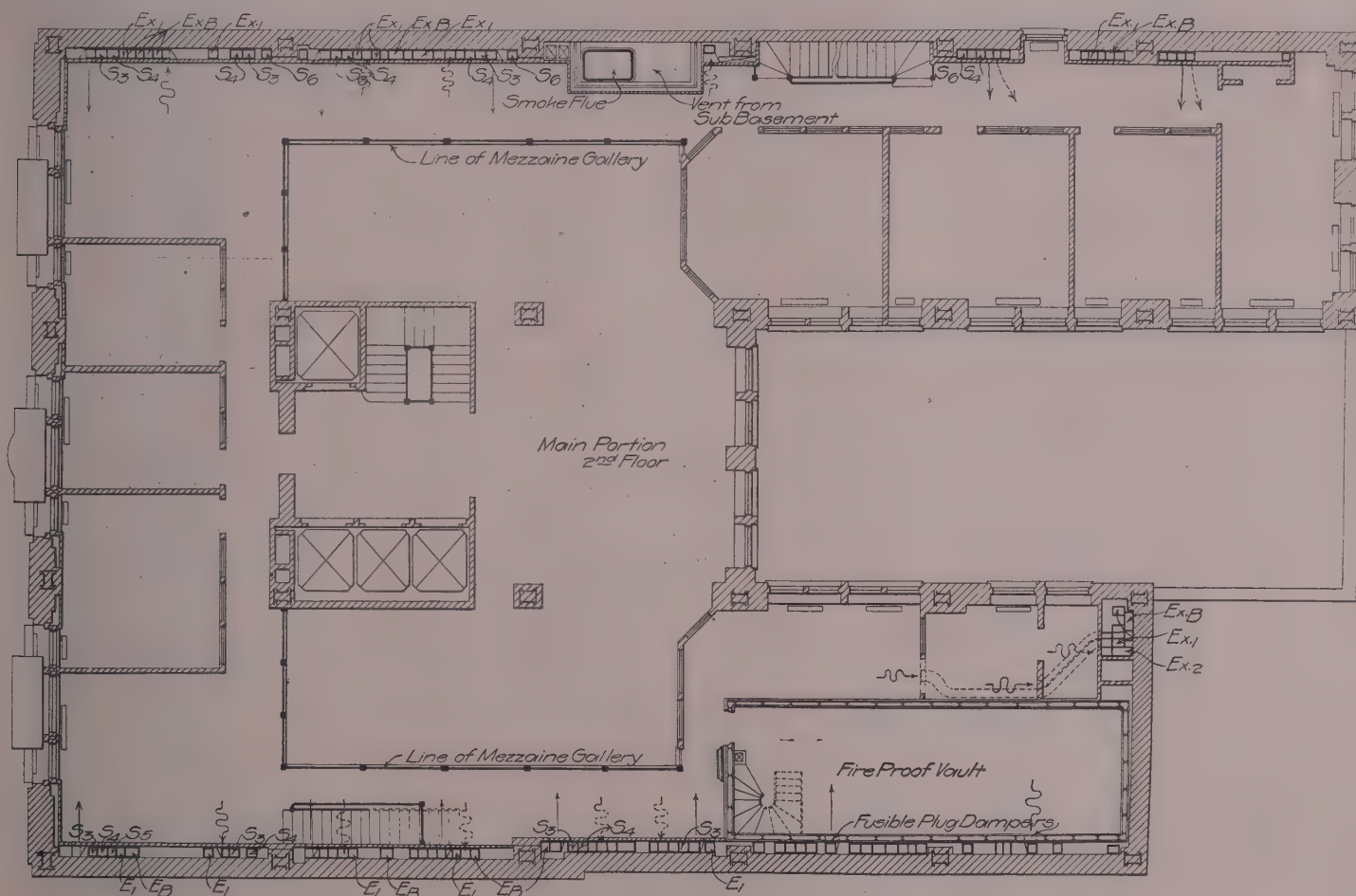
delivers 13,000 cu. ft. The sub-basement cool air is furnished by a fan with $5\frac{1}{2}$ -ft. wheel, 32 in. wide, fitted into a casing of the size ordinarily provided for a 5-ft. fan; it is operated at 200 r.p.m., at which it delivers 12,000 cu. ft. Both of these fans are full-housed Sturtevant blowers of the top horizontal discharge type and are driven by C. & C. motors, 5 h.p. in size for the basement fan and 6 h.p. for the sub-basement supply.

Fresh air is drawn through a $3\frac{1}{2} \times 22$ -ft. intake shaft at the rear of the building on the north side, which is carried up from the sub-basement to the first floor level, opening into an areaway at the rear of the building. The shaft has swinging dampers at its base to prevent admission of cold air in winter if it is desired to shut down the fan systems, and opens into a

in all of the air supply systems for the upper floors, the system for the sub-basement being merely for fresh air. The coils are located, in all cases, in the intake connections between the filter chamber and the fan, and have a heating surface of 1,190 sq. ft. for the 7-ft. blower, 1,122 sq. ft. for the 6-ft. blower, and 598 sq. ft. for the $5\frac{1}{2}$ -ft. blower for the basement and vaults. All coils are 1-in. pipe screwed into separate cast iron headers of the standard Sturtevant construction. Either two or three outer sections are controlled by a cold air thermostat and three or four inside sections by an inside thermostat in the delivery duct. Steam is supplied to the coils from the low-pressure heating system of the building under control of Johnson thermostats and motor valves. The air moisteners are the standard Johnson humidifier type, consisting of

in. branch in the sub-basement extending to the south side wall to supply six 10x10-in. riser flues to the vaults on the upper floors. The basement supply riser from this system is divided at the basement ceiling into a 14x36-in. distributing duct for the south half and a 13x36-in. duct for the north half. These main ducts have branches to every room. The cool fresh air supply for the sub-basement is similarly arranged, the blower discharging through a 22x42-in. duct on the ceiling which extends into the elevator pump room with numerous outlets and thence to the boiler room at the front. These fan systems are all proportioned for velocities of flow ranging from 1,500 to 2,000 ft. per minute at the blower outlets to 1,000 ft. in the distributing ducts and 700 ft. in the delivery branches.

The two 72-in. Blackman disk exhaust fans



Plan of Second Floor Showing Details of Heating and Ventilation.

filter chamber extending entirely across the sub-basement. Through the middle of this chamber are located the filter frames, arranged in the usual zig-zag form, with cheese-cloth medium mounted on removable wooden frames. There are 40 frames $3\frac{1}{2}$ ft. wide in the southerly half of the chamber where there is a head-room of 9 ft. and 42 frames 4 ft. in width in the northerly half where the head room is but 8 ft., which together present an aggregate filtering area of about 2,000 sq. ft. and thus permit an average filtering velocity when all fans are operated to maximum capacity of less than 40 ft. per minute. The frames are fitted air-tight into galvanized iron supports and the frames have wire-netting backing for the cheesecloth, which latter medium is cleaned by the vacuum process, hose connections from the vacuum cleaning system being provided in the chamber. This chamber furnishes air to the 7 and 6-ft. fans which supply the north and south sides of the upper floors, and the $5\frac{1}{2}$ -ft. fans which supply the basement, upper floor vaults and sub-basement.

Tempering coils and air moisteners are provided

copper evaporating fans fitted in the bottom of the intake connections between the tempering coils and the blowers, and fitted with a steam coil of brass pipe for evaporation of the water as required to add moisture to the air. High-pressure steam is admitted to the coil under control of Johnson humidostats in the delivery ducts and so connected as to operate the supply and return valves on the evaporating coils as required. Water is maintained in the evaporating pans by float valves supplied from the water service of the building.

The distribution ducts from the 7 and 6-ft. fans are arranged on either side for convenience of connections to the riser flues in the side walls. The risers are rectangular galvanized iron flues 8x10-in. to 14x16-in. in section. There are 32 of the risers in the south wall and 30 in the north wall. The $5\frac{1}{2}$ -ft. fan which supplies fresh air to the basement and upper-floor vaults on the upper floors, delivers through a duct 36-in. square, which is extended to one side of the building where a 27x36-in. uptake is carried up to the basement distributing system, with a 10x36-

are on the roof, and draw from the vent registers on the various floors through a system of ducts arranged like those for fresh air. They are in pent houses on either side of the interior court, and have connections to the flue risers, which are furred into the side walls through a galvanized iron gathering duct carried on the ceiling of the pent house forward to the front of the building. Each gathering duct is approximately 28 sq. ft. in cross section, tapering in size toward the front of the building. The exhaust capacity provided is nearly equal to the fresh air supply, the fan serving the south side of the building, which has relatively less ventilated volume than the north side, being equal in size to that serving the north side on account of the extra duty imposed in the ventilation of the vaults in that section. To save room the fans are arranged vertically in the bases of the copper discharge hoods in the roof of the pent houses, being driven by 6-h.p. vertical-shaft C. & C. electric motors on the floor below. The motors are designed for a maximum speed of 250 r.p.m., at which speed the fans have a capacity of about 30,000 cu. ft.

per minute, or about 15,000 cu. ft. each.

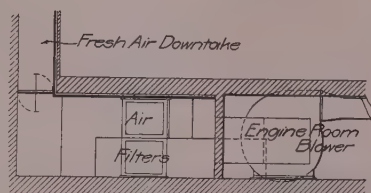
An interesting feature has been introduced in connection with the ventilating equipment in the form of a room for quickly drying in wet weather the garments of employees upon entering the building for work. The equipment consists of a series of registers in a room in the basement toilet room, through which highly heated fresh air is forced by a special fan equipment in the basement, so that by standing over them a short time, wet garments may be rapidly dried out. The room is 13x15 ft. and contains fourteen 12x12-in. registers mounted in a wooden platform 15 in. above the floor line which extends around the sides of the room. The distributing ducts underneath the registers are supplied by two 12x12-in. connections from a No. 6 Monogram pressure blower in the sub-basement, which, at maximum capacity, delivers 14,000 cu. ft. per minute at an average delivery velocity from the registers of 1,000 ft. per minute. The fan has its intake through the filter chamber utilized for the larger fans of fresh air systems, to which it is connected by a 12x24-in. duct, and is driven by an 8-h.p. direct-connected C. & C. motor running at 1,100 r.p.m. The air is warmed by a Sturtevant pipe heater having a total surface of 278 sq. ft. The system is found very effective and satisfactory.

The heating of the building is accomplished by direct radiation throughout, utilizing exhaust steam at low pressure from the pumps and auxiliary machinery, with make-up from the high pressure steam mains when required. The design of the heating equipment proved comparatively simple, owing to the fact that there is exterior exposure only on the street front and the rear portion facing the interior court, either side being hemmed in by taller buildings. Accordingly direct radiation has been disposed under windows as required to counteract direct exterior glass exposure, with supplementary skylight radiation where required. No radiation has been installed along the side walls except at one point near the rear end of the northerly wall which faces a narrow court on the adjoining property; on each of the floors above the second, there is a 36-in. window opening into this space, which is served by a 40 sq. ft. radiator under the sill. The radiation at the front and rear walls is distributed nearly equally under all windows, the greater amounts being however, on the main floors in the large single-story sections, 22 to 24 ft. in height, which occur in the front portions of some of the first four floors. The typical distribution of the radiation is shown on the accompanying second floor plan, this floor having a large open central space 22½ ft. in height at the rear of the elevator enclosure, with mezzanine galleries 11½ ft. above the floor level occupying the rear wings and the extreme front of the floor. On the first floor, however, there is no mezzanine gallery in the forward portion and on the third and fourth floors the mezzanine at the front occupies but a portion of the floor, so that the heating conditions are altered somewhat, requiring greater radiation on the main floor level at those points. At the rear, each of the mezzanine floors has a continuous mezzanine entirely surrounding the interior court area, which areas were treated as separate floors in proportioning radiation, necessitating, in effect, the heating of four extra floors.

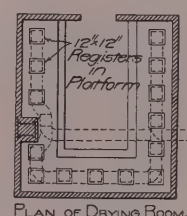
Peerless radiators are used in the one, two or three-column patterns, and are installed under window sills. They are supplied with low pressure steam from the power plant by seventeen riser lines, three of which extend only to the first floor to supply sky-light coils and rooms on that floor under the sky-light of the court. The risers have loop expansion joints in spaces under fourth floor and are carried up into the pent house on the roof and capped there, to provide for

extension if at any future time the building shall be raised. The risers are paralleled by return risers in all cases. The supply and return risers connect in the sub-basement to distributing and gathering mains respectively, the former connecting with the low pressure exhaust steam header in the power plant, and the latter with the return pumps. The return gathering mains are run below the water level maintained by the pump governor, so as to secure a sealed return in all branch connections. All radiation, both direct and that for the fan system, is fitted with the Paul vacuum system, with the usual exhauster equipment in the sub-basement, with air lines and special air valves on all radiators and heating coils.

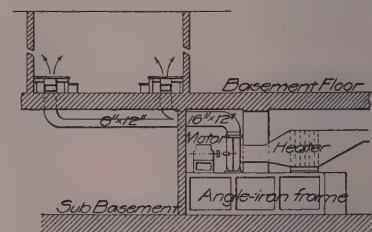
The steam plant from which low-pressure steam is furnished for heating is located, together with the fan equipment, in the sub-basement. It consists of two 180-h.p. boilers, in a room in the forward portion of the sub-basement. While the space allotted to the boilers is comparatively small, consisting of a passage 18 ft. in width extending crosswise of the building, with an extension from the middle, 20 ft. square, out under the side-walk space, it is rendered unusually convenient by the ample head-room, the floor of the boiler room being depressed some 6 ft. be-



Details of Fresh Air Intake.



Details of Wet Garment Drying Station.



low that of the remainder of the sub-basement. The greater part of the boiler room is well lighted by large side-walk lights above the 20-ft. extension. In the latter there is a 20-ft. gallery 10½ ft. above the boiler room floor which accommodates the toilet and wash rooms of the engineers and assistants. The coal storage takes up the remaining space under the sidewalk on either side of the boiler room extension, which together aggregate in floor space over 500 sq. ft., providing storage for nearly 200 tons. Additional space was secured for the boiler auxiliaries by a 11x15-ft. extension from the southerly end of the boiler room under the elevator room on the main sub-basement level; while a head-room of but 8 ft. was here available, the feed and return pump and the drip and blow-off tank were located there, much to the convenience of the boiler room lay-out.

The boilers are the Babcock & Wilcox cross-drum type, arranged cross-wise of the building in either end of the boiler space, facing a central firing floor which connects with the boiler room extension through which access is had to the coal bunkers. There are 108¼-in. tubes 12 ft. in length, expanded into the usual serpentine headers, which present a total of 1,809 sq. ft. of heating surface. The steam drums are 42 in. in diameter by 8½ ft. long, of ½ in. steel, and are arranged cross-wise at the rear of the boiler settings. The boilers are fitted with plain grates of 88 sq. ft. surface for hand firing, and smoke is removed by an overhead breeching with 39x60-in. connections to the rear of each setting. The main flue is a rectangular duct 36x48 in. in section and extends back to a flue of similar size in a pipe shaft enclosure in the middle of the north wall of the building in which it is carried up to a point above the adjoining roof line, some 200 ft. above the grate surface. The boilers are of standard high-pressure construction throughout so as to permit operation with higher pressures than at

present if it is desired to install electric generating machinery in the power plant. Coal is dumped through side-walk coal holes directly into the bunkers and is taken to the firing floor in barrows. Ashes are removed in cans to the sidewalk by a 3½x6-ft. plunger sidewalk elevator in an enclosure to the south of the boiler room extension under the sidewalk.

For feeding the boilers there are five 6x4x6-in. duplex pumps, two of which return from the tempering coils, two from the high-pressure drip tank and heating system, while the fifth is utilized for handling fresh water to the boilers. The two pumps serving the tempering coils are under automatic control of a pump governor and the other two serving the heating system and drip tank are similarly controlled for automatic return of condensation as fast as it accumulates. These pumps as well as also the blow-off and low pressure drip pumps are brass-fitted Worthington pumps designed for 150-lb. pressure and are cross connected in a number of ways to permit of maximum flexibility in operation. The pumps deliver to the boilers through a 2½-in. brass feed main with a 2-in. branch to each unit with double stop valves and check valves between. The pump feeding equipment is supplemented by a No. 8 Monitor Nathan injector

on each boiler which has independent steam connections and suction from the cold water piping of the building and delivers to the feed branch connections so as to be used independent of outside assistance if desired. The boilers have 2½-in. blow-off connections to a main leading to a 3½x7-ft. tank at the rear corner of the boiler room, with coils for cooling the discharge according to the city regulations; as this tank is below the level of the sewer in Broadway, a 6x5¾x6-in. brass fitted pump is installed to raise the blow-off discharge to the sewer. The blow-off tank, as well as also the high and low-pressure drip tank, has cooling coils of 3-in. brass pipe through which cold water is passed to the hot water heater of the plumbing system, for reclaiming heat which would otherwise be wasted through these tanks.

The steam piping of the plant is greatly simplified by the absence of electric machinery, although the headers and connections have been laid out for the possible future use of such machinery. The high pressure system consists of an 8-in. line from the boilers to a header at the engine room wall, the boiler connections consisting of 6-in. branches with long radius bends to the drum nozzles. The header is a gun-iron drum 12 in. in diameter with three outlets, a 5-in. main for live steam to reducing valves to the heating system, a 4-in. line for high-pressure steam to the feed and return pumps and a large elevator pump, and an 8-in. blanked outlet for connection to a possible future engine room delivery main. The low pressure header is a cast-iron drum 12 in. in diameter having four openings, two of which are 10 in. and connect with the live steam supply connection and with the exhaust main from the pumps while the other two are 8-in. connections which supply the two distributing mains of the low-pressure heating system. The exhaust main is a 5-in. line leading from the pumps, first to a 2½x5-ft. Utility muffler tank and thence

through a closed feed water heater to the low-pressure header. A 5-in. branch from the low-pressure header extends through a back pressure valve to a 10-in. exhaust riser in the smokestack shaft to the atmosphere, which was installed to facilitate the possible addition of generating machinery.

The heating and ventilating equipment and steam plant were designed by Mr. Alfred R. Wolff, consulting engineer, New York. The equipment was installed by the Thompson-Starrett Co., who were general contractors for the construction of the building. The architects of the building are Howells & Stokes, New York.

The Septic Tanks at Malvern, England.

In connection with recent improvements to the sewage disposal works of Malvern, England, two contiguous concrete septic tanks have been built with unusually light walls, reinforced according to the Hennebique system. Each tank is 121 ft. 1 in. by 31 ft. 6½ in. inside and holds 9 to 11 ft. of sewage, the two having a combined capacity of about 475,000 imp. gal. The floor of each tank has a fall of 24 in. from the outlet to the inlet end and a transverse slope of 9 in. from the outside wall to the longitudinal central partition wall between the tanks. Sewage enters the tanks through several pipes, arranged to distribute the flow as much as possible, and leaves through similarly placed openings delivering into a reinforced concrete channel shown in an accompanying illustration.

The floor is 5 in. thick and is reinforced longitudinally and transversely in both upper and lower surfaces, with 5/16-in. to 7/8-in. round bars spaced 8 in. The floor slab extends 2 ft. 1 in. beyond the outer face of the enclosing walls, except at the inlet end. The walls are 5 in. thick and are reinforced with round bars on both sides and with counterforts attached to the floor projection and spaced about 5½ ft. center to center, except at the inlet end, where no counterforts are needed, according to "The Surveyor," from which these notes have been taken, because at that end there is no inward earth pressure. To the lower side of the floor slab under each counterfort is attached a reinforced rib about 12 in. deep to provide for stresses developed near the toe of the counterfort.

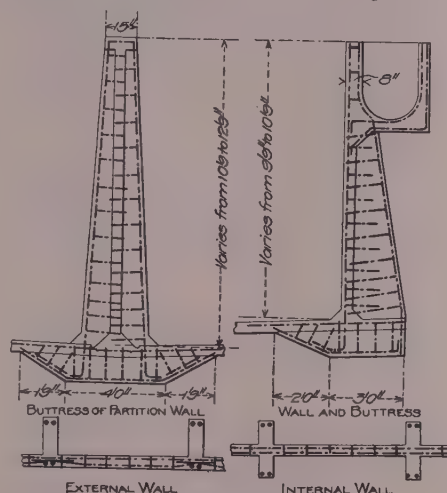
The partition wall between the two tanks is 5 in. thick and is reinforced like the outer walls, except that it has buttresses on both sides as shown in an accompanying illustration. The effluent channel is supported partly by the counterforts and partly by the earth fill outside, but it is reinforced enough to make it substantial without the support of the ground. The Malvern septic tanks were designed by Mr. L. G. Mouchel and built by the Liverpool Hennebique Ferro-Concrete Contracting Co.

THE MASSACHUSETTS AUTOMOBILE TRAFFIC is so heavy that it has caused marked wear on the State highways, and the commission having charge of these roads states in its last annual report that the destructive effect is "extraordinary." Practically all the main roads are thus affected. It has been noticed that the binder is swept from the road, and the stone from ½ to 1½ in. in size has been disturbed, in some cases standing on the surface, and in other cases being left in windrows along the roadside. The effect of wear of this sort is such that the commission is satisfied a material change in the methods of maintaining stone roads must be made. The report indicates that the commission believes some kind of treatment with tar will probably be successful. It may be mentioned also that "The Horseless Age" has called attention recently to important legal aspects of the dust nuisance.

The Application of the Federal Eight-Hour Law on Dredgers.

The full text of the opinion of Mr. Justice Holmes, of the Supreme Court of the United States, in the cases of William H. Ellis, Eastern Dredging Co., and the Bay State Dredging Co., respectively, against the United States, has just been received. These were cases involving the constitutionality and scope of the Federal eight-hour law. The opinion of the court is concurred in by six of the judges. Mr. Justice Moody, formerly Attorney General, filed a dissenting opinion with the concurrence of two other judges upon certain of the points decided.

The first question discussed by the Supreme Court is the constitutionality of the eight-hour law. The court declares that this has already been substantially passed upon in the case of *Atkin vs. Kansas* (191 U. S. Rep. 207) involving the constitutionality of a similar law of the State of Kansas. The court holds that there is no substantial distinction between the powers of



Septic Tank Wall.

the State and the powers of the United States to pass a law forbidding work in excess of eight hours upon contracts with the State or with the United States respectively. The constitutionality of the act is therefore upheld by the Supreme Court of the United States. The decision in this respect supports the view expressed in an elaborate discussion of the constitutionality of this law in the issues of this paper of Sept. 8th and 15th, 1906, by a regular contributor, Mr. William B. King, of Washington, D. C.

The constitutionality of the act being disposed of, the next question was as to the meaning of the exception to the act permitting labor in excess of eight hours in case of extraordinary emergency.

In the William H. Ellis case, one of the parties accused pleaded that he was obliged by his contract to finish his work within a fixed period, and that unexpected difficulty was found in getting material and that delay had ensued, resulting in the necessity for the employment of men for nine hours a day in the hurry to get the pier constructed. The trial court held that this did not show an extraordinary emergency and the Supreme Court of the United States affirmed this ruling in the following language:

"The ruling was correct. It needs no argument to show that the disappointment of a contractor with regard to obtaining some of his materials, a matter which he knew involved some difficulty of which he took the risk, does not create such an emergency as is contemplated in the exception to the law. Again, the construction of the pier was desirable for the more convenient repair of warships, but it was not essential. Vessels had been docked without it since 1835 or 1836, so that

there was no hot haste on that account, if under any circumstances that kind of need would have been enough."

The judgment against Ellis was therefore held to be correct.

In the other cases where men were employed more than eight hours in work upon dredge boats in Boston Harbor engaged in dredging a channel, two points were raised against the application of the eight-hour law to these. The first was that the dredging of a channel cannot be included in the term "any of the public works" of the United States. The opinion upon this subject says:

"The fact that the persons mentioned as employed upon them are laborers and mechanics, words admitted not to include seamen, points in the direction of structures and away from the sea. The very great difficulty, if not impossibility, of dredging in the ocean, if such a law is to govern it, is a reason for giving the defendants the benefit of a doubt; and the fact that until last year the Government worked dredging crews more than eight hours is a practical construction not without its weight."

The conclusion was reached that dredging in a river or harbor channel was not within the statute. Upon this point, the three judges dissented and insisted that a channel was one of the public works of the United States just the same as a jetty or pier.

The opinion then took up the question of the words "laborers and mechanics" and considered the question raised in this case whether men working on the dredge boats were included within this term. It was stated that these dredges were vessels under the definition of the Revised Statutes of the United States and within the admiralty jurisdiction of the United States, and that it had been held that all work on them for certain purposes should be considered seamen. Upon this subject the opinion concludes as follows:

"They all require something of the training and are liable to be called upon for more or less of the services required of ordinary seamen. The reasons which exclude the latter from the statute apply, although perhaps in a less degree, to them. Whatever the nature of their work, it is incident to their employment on the dredges and scows as in the case of an engineer or coal shoveler on board ship. Without further elaboration of details we are of opinion that the persons employed by the two defendant companies were not laborers or mechanics and were not employed upon any of the public works of the United States within the meaning of the Act. As in other cases where a broad distinction is admitted, it ultimately becomes necessary to draw a line and the determination of the precise place of that line in nice cases always seems somewhat technical, but still the line must be drawn."

Upon this point also Justice Moody and two other judges dissented, believing that a man working on a dredge was a laborer just as much as another working upon an adjacent breakwater.

The result of this opinion is to sustain absolutely the constitutionality of the law, but to relieve from its application all dredgers and other persons working upon floating structures.

CONCRETE ABUTMENTS of structures in salt water built for the Massachusetts Highway Commission showed some disintegration in earlier masses of masonry, and for this reason on all such work at the present time a mortar of one part of cement and one part of sand has been used on the face to the depth of about 1½ in. This is placed by using a thin metal diaphragm separating the richer front mortar from the standard concrete, and withdrawing the diaphragm when the concrete is in place and before it has set appreciably.

The Baltimore & Ohio Office Building, Baltimore.

The Baltimore & Ohio Railroad Company's building, Baltimore, has been erected for the general offices, and the engineering, commercial and freight departments of the company. It occupies a 150x160-ft. site and is 13 stories and basement in height. It is H-shaped in plan, consisting of two 48x160-ft. wings, connected by a central 42x76-ft. wing and separated by two 42x42-ft. courts. This provides for a corridor in the center of each of the three wings, giving access to the rooms, all of which have outside exposure. The elevators, stair-shafts, toilet-rooms and other public portions are in the central wing, which is isolated from the main wings devoted to offices by fire walls extending from basement to roof and provided with iron doors glazed with wire glass so that it is considered impossible for a fire to spread from one part to another of the building.

The exterior walls from the pavement to the top of the belt just below the third story windowsills are faced with North Conway, N. H., granite; and the walls above this point, to the main cornice over the thirteenth story windowheads, are faced with gray Bedford limestone. The cornice and the parapet above the main cornice are of semi-glazed, architectural terra cotta of the same color as the limestone. The entire exterior stonework and terra cotta is backed with hollow brick masonry. On the top of the building is a pent house, with walls of hollow terra cotta covered with cold-rolled copper.

All the exterior corners of the building are cut off at an angle of 45 degrees, the object being to obtain more light and air, especially in the central portion of the building.

There are three main entrances to the first floor and corner entrances at each of the wings.

Eight passenger elevators are located in the center of the building, four on each side; and there is a large freight elevator at one end of the same corridor, as well as a service lift. Two large staircases lead from one of the street entrances to the second story and two service staircases lead from the basement to the pipe chamber, one of them continuing to the pent house. An oriel staircase leads from the second to the thirteenth floor, on the west court.

Commencing with the first floor, and continuing throughout each of the thirteen floors, there are two large general toilet rooms opening off the main corridors. The walls and partitions in these rooms are of white marble, the floors of white tiling.

On the south side of the twelfth floor of the building is a kitchen and lunch room seating 75 persons. There are also a general dining room and three private dining rooms on the same floor.

The various office rooms are provided with white marble lavatories, hot and cold water, and ice cold filtered drinking water. Each of the officers' suites are provided with private bath rooms.

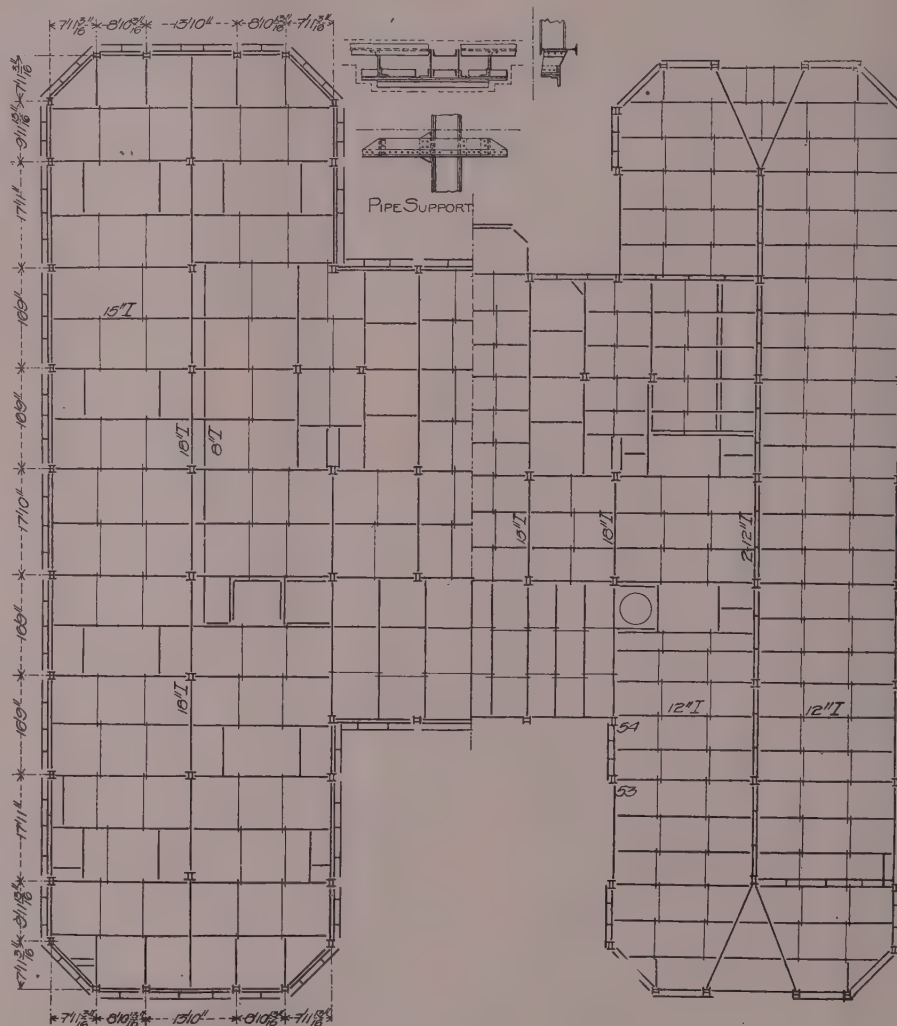
All floors are of hollow terra cotta ties, filled in on top with cinder concrete with a top finish of Portland cement, excepting the corridor floors, which are finished with marble tile, the allowance room floors, which are finished with selected oak, and the toilet room floors, which are finished with hexagonal tile. The partitions throughout are fireproof tile, while the roofs are finished in actinolite embedded in cement.

The outer windows, except the very large ones on the first floor, are protected by wire glass, and all windows in the corridors have wire glass. The first story windows have cast iron frames and copper sash and in all upper stories both window frames and sash are of heavy sheet copper. The small amount of wood in the building is treated by a fire-proofing method. All steel-work is inclosed in tile jackets.

The steam, water and drainage piping have the upper connections in a special pipe chamber between the ceiling of the fourteenth story and the roof. The elevator, pumping, refrigerating, transformer, fan and pneumatic machinery is in the basement, which was designed in the first place for its reception and more space and height were provided for it than is usually found in office buildings. All basement doors are double, the outer door having fusible plugs to insure automatic closure in case of fire.

The water supply from the street mains is passed through two large filters and into a basement storage tank of 30,000 gal. capacity and

rent at 110-220 volts, for three wire distribution in the building. The power load consists of nine motors ranging from 1 to 5 h.p. direct-connected to ammonia, ice water, brine and sump pumps and several exhaust fans; nine motors ranging from 7½ to 10 h.p. direct-connected to house pumps, pneumatic tube pumps and vacuum pumps for the sweeper system, printing press and several ventilating blowers; and eighteen motors ranging from 15 to 30 h.p. direct-connected to eleven electric elevators, fire pump, and other machines. The lighting of the office section of the building is divided longitudinally into two zones, each half of every floor being separately



Typical Beam Plan, Baltimore & Ohio Building.

then is pumped into a tank in the pent house. The street mains are also connected to a fire pump having a capacity of 1,650 gal. per minute.

The Paul vacuum heating system is installed with cast iron radiators in all the rooms of ample size to maintain a temperature of 70° when the outside temperature is zero. In addition to the direct heating equipment, there are two large blowers in the basement receiving the outside air through a filter and washer and passing it through heating coils and galvanized iron distributing ducts.

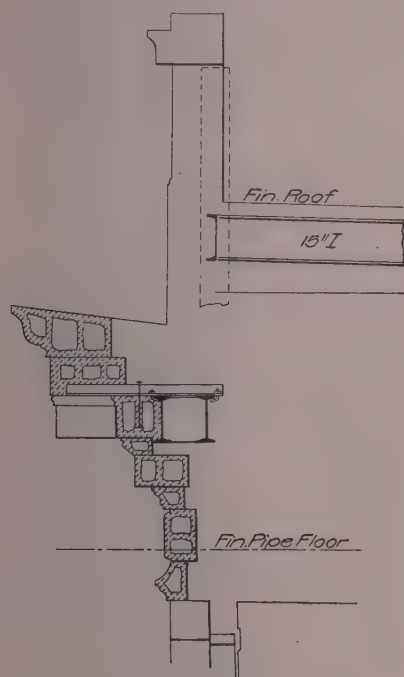
A complete system of vacuum cleaning has been installed, and also a pneumatic tube service by means of which all mail, orders and instructions coming to the central office on the mezzanine floor are assorted and sent to the various floors.

At present the electric power is supplied from the local electric light company, but it is the ultimate intention of the railroad company to supply current from its Camden St. power house, and the switchboard is designed with this end in view. Static and rotary transformers will be located in the basement; current will be supplied at 6,600 volts, three-phase, and transformed to direct cur-

controlled from the switchboard. In addition to this, all the halls and corridors come within the public zone and are on a separate feeder so that they also can be separately controlled. The lighting scheme is considered unique, in that the lights are not grouped in fixtures, but are studded in the ceilings of the various rooms, averaging about 2½ watts per square foot. This insures an even distribution of light, and the elimination of all shadows. There are 4,500 62½-watt and 125-watt high-efficiency lamps used throughout the building.

In order to avoid marring the completed building by running additional telephone, telegraph and call bell wires, of which there must of necessity be a great number installed and constantly changed in a building of this type, it was necessary to devise a system of interconnection, the main feature of which should be flexibility and adaptability to meet the most severe conditions. This problem has been solved by a system of 1 in. square ducts run in the concrete floors, their tops flush with the finished surface of the floor. These ducts are run at right angles to one another, and parallel to the walls. At each inter-

section, a specially designed floor junction box is installed with a removable cover flush with the floor, permitting access to the wires at those points. As these ducts are only 4 ft. apart in one direction, and 15 ft. in the other, it can be readily seen that no matter how a desk may be placed, it will cover or at least come very close to one of these floor ducts. The finished granolithic floors are covered with $\frac{3}{8}$ -in. thick linoleum, and in making a connection, the No. 20 gauge floor duct is located and pierced through the linoleum, a special bushing inserted, and the necessary wires brought through it to connect with the telephone, telegraph, bell, instrument or fixture placed on the desk or table. At the end of each run of floor duct, the duct turns up to a terminal outlet box in the baseboard. These baseboard outlets are connected by $\frac{1}{2}$ -in. conduit behind the picture moulding, and each of these in turn is connected with the main interconnection centers, two of which are located on each floor. Risers of 3-in. conduits connect the main



Cornice and Parapet Construction.

interconnection boxes on the various floors. In addition all interconnection outlet boxes behind picture moulding are interconnected by vertical conduits rising through the building from the bottom to the top, allowing direct connection between any two or more points without running to the interconnection center.

Besides these systems, trunk line conduits are run from the telephone switchboard and the telegraph room to the basement where connections are made to the outside wires in the subways. A watchman's clock system is also installed, with three stations on every floor, which insures the faithfulness of the night watchman in making his rounds. Power for this as well as the call bell, telegraph and telephone system is supplied by two motor-generators.

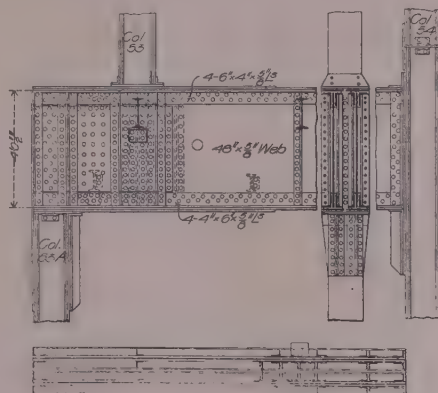
Some idea of the magnitude of the electrical installation may be obtained from the fact that 100 miles of conduit, and 300 miles of wire were used in the electric light and power installation alone, besides 20 miles of conduit and square floor duct for the interconnection system. For its maintenance, a workshop has been fitted up with a 16-in. lathe, 20-in. swing drill, and bench emery grinder, each equipped with an individual direct-connected motor.

Some of the quantities of materials in the construction of the building are: 10,000 bbl. of

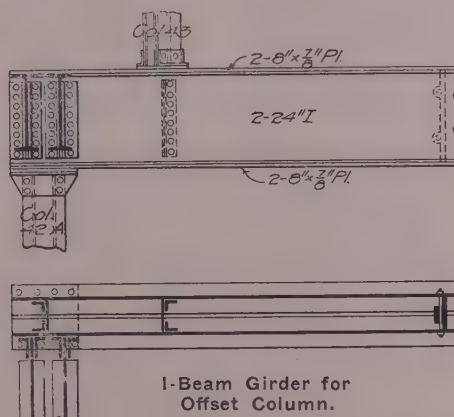
Dragon Portland cement, 20,000 loads of sand, 983 tons of crushed stone, about 2,674,000 bricks, 1,630 tons of Bedford limestone, about 11,000 yards of galvanized lath and 40 tons of light iron for furring. About 450 tons of ornamental iron and bronze work, about \$6,500 worth of polished glass in the elevator fronts, and about 35,000 ft. of wire glass.

The 800 lineal feet of terra cotta cornice and balustrades was furnished by the Excelsior Terra Cotta Company, of New York.

The basement is about 17 ft. deep below curb level, and is extended beyond the building line, the sides being retained by concrete walls reinforced with vertical 12-in. I-beams 5 ft. apart, connected at the top and bottom with horizontal



Box Girder for Offset Column.



1-Beam Girder for Offset Column.

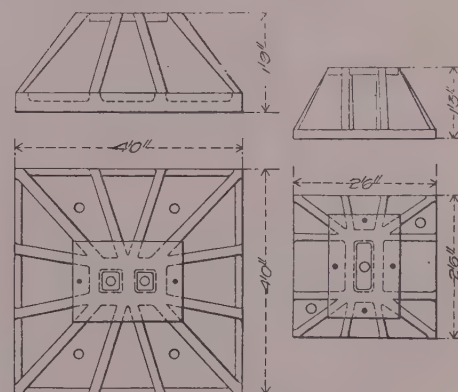
channels and supporting on their upper ends the outer ends of the steel floorbeams carrying the concrete sidewalk slabs. All column foundations are square concrete piers made with three to five 12-in. offset courses, the upper ones being flush with the cellar floor and capped with cut granite stones or in some cases with grillage beams receiving the cast-iron pedestals for the columns. In most cases each pier receives a single column, but in a few instances they receive pairs of columns, each of them seated on a set of grillage beams together forming a balanced distributing girder across one end of the pier.

The cast-iron pedestals are 2½ to 4 ft. square and have top and bottom horizontal plates connected by transverse and longitudinal vertical webs, intersecting at the center where they form one or more chambers, and braced on the outer side by diagonal or oblique webs. All of the bottom plates are pierced with 2-in. grouting holes and the top plates are drilled to receive connecting bolts in the bases of the steel columns. The large pedestals are peculiar in that none of their webs are at right angles to the bases, but all are oblique and radiate somewhat irregularly, as indicated in the typical drawing. The smallest columns have solid cast-iron bed plates 3 in. thick, with bevelled edges, instead of pedestals, which are designed to be thick and strong enough to

distribute the weight of the columns over a width of footing 10 in. greater than the bottom of the column.

The framework is of simple standard construction and has 86 columns with closed rectangular sections built of pairs of channels and cover plates. All columns are centrally loaded except as the requirements of the wall girders make them eccentric, and most ordinary beams and girders are single I-beams connected to the columns on the centers of the faces of the latter and supported by bracket angles with reinforced horizontal flanges forming shelves. Where the girders consist of pairs of I-beams there is a vertical reinforcing and distributing angle riveted to the column in the plane of each web. Short horizontal angles are shop-riveted to the columns to engage the top flanges of all connected beams and girders. Column splices are made at every second story with jaw plates shop-riveted on the cover plates of one section of the column and with short horizontal flange angles riveted to the column webs just above floor level.

In the second and sixth stories the column spacing changes, and the columns in the upper part are offset from the lower ones and are carried on plate girders connecting and supported by the lower-story columns. Columns 28 and 53 are carried by double-web second-story plate girders 48 in. deep, each having four 6x4x $\frac{5}{8}$ -in. flange angles, four 9x $\frac{3}{4}$ -in. flange plates and two 35x9/16-in. web reinforcement plates at the end bearings. One end of each girder is seated directly on top of the adjacent column and the



Typical Cast Column Base

other end is provided with vertical web angles, through which it is field-riveted to the cover plates of the adjacent column, where it is also seated on horizontal shelf angles with projecting flanges, reinforced by pairs of vertical distributing angles shop-riveted to the columns.

The sixth-story columns, 20, 21 and 22, are similarly carried by girders 38 in. deep, which, however, are supported at both ends on the tops of five-story columns. The intermediate columns are seated on the centers of the top flanges of the girders, and the latter have four 6x4x $\frac{7}{8}$ -in. flange angles, four 10x $\frac{3}{4}$ -in. flange plates and one 38x $\frac{3}{4}$ -in. web plate. Double pairs of 3x4-in. vertical angles are riveted to the web to provide for shear at the points of load concentration.

Columns 43 and 44 are supported at the second floor level on pairs of 24-in. I-beams, seated at both ends on the horizontal cap plates of the second-story columns. Over the tops of the columns they are web-connected to pairs of 20-in. I-beams in the opposite directions, and at these points and under the seats of the upper story columns the webs of the 24-in. I-beams are connected by riveted diaphragms, intermediate connections between their webs being made with standard cast-iron separators and bolts. The second story columns 42 and 45 are supported similarly to 43 and 44 except that the span being

shorter, they are carried by pairs of 20-in. I-beams which at one end are connected to shelves on the bases of the supporting second story columns and the other end are web-connected to pairs of 24-in. I-beam girders.

In the lower stories the beam framing is somewhat special, but above the third story it corresponds exactly to the plan shown, which is symmetrical about the center line. This arrangement provides for wide spacing in the side wings, where a center row of columns carries a double line of longitudinal girders, terminating some distance from each end of the wings where the floor is carried by a rather peculiar arrangement of diverging beams reaching to wall columns spaced eccentric from the interior columns to be in accordance with the architectural requirements. The roof loads are not as heavy as the floor loads, and are provided for by a lighter system of beams. The wall girders are of ordinary construction, made of beams and channels, offset from the column centers and provided, when necessary, with horizontal shelf angles riveted to their webs.

Several of the street wall columns are inclosed in wide, flat, external piers or buttresses supported at every story on shelves made with long, horizontal angles connected by vertical angles to the columns and also connected by transverse vertical diaphragm plates to the webs of the wall girders, as shown in the accompanying detail. Many of the lintels are made of pairs of 6x4-in. angles, back to back, with connection plates riveted between their vertical legs and engaging double bent plates fitted over the bottom flanges of the I-beam wall girders above forming hangers to suspend them in position.

The cornice is about 8 ft. high with an overhang of 4 ft. and is built up of several courses of hollow terra cotta blocks, seated on or anchored to a course of 4x4-in. horizontal angles 3 ft. apart, projecting across the top flanges of a pair of wall girders in the space between the pipe floor and the roof. These angles form cantilevers secured to the girders with hook bolts and having suspension bolts passing through their horizontal flanges between the fulcrums and outer end to sustain the lower courses of the terra cotta. The wall columns extend above the tops of these double girders to a point about 3 ft. above the finished surface of the roof and thus serve as stiffeners and support for the parapet wall, inclosing the flat roof.

The building contains about 4,000 tons of structural steel and its cost, exclusive of site and inclusive of equipment, was about \$1,600,000.

Messrs. Parker & Thomas and Hale & Morse were the associated architects, and Purdy & Henderson were the consulting structural engineers of the building, the construction of which was, for the Railroad Company, under the direct supervision of Mr. J. E. Greiner, assistant chief engineer in charge of bridges and buildings, and Mr. M. A. Long, architect. The Wells Bros. Co., New York, was the general contractor and the structural steel work was furnished and erected by the American Bridge Co.

WATER SOFTENING REACTIONS are notoriously delicate, a fact emphasized by the experience with the softening method at Oberlin, Ohio, last summer. The process of softening followed there was described in this journal on Oct. 7, 1905, the water being treated in two settling basins. During last August it was discovered that if all the chemicals for the day were put into one-half the water and the other half was allowed to flow into the first basin without chemicals, there would be no caustic alkalinity in the water, after mingling and treatment and the magnesium would be reduced from 22 to 1.5 parts per million. It had previously been impracticable to remove so much magnesium, as the caustic alkalinity would rise too high.

The Design and Construction of Foundry Buildings.

A paper read before the Philadelphia Convention of the American Foundrymen's Association, by Geo. K. Hooper, Consulting Engineer, New York.

The foundry business has become so specialized and such rapid strides have been made in the elementary knowledge of the methods and requirements of manufacture that it is difficult to make any general remarks on the subject of foundry construction. I will, however, endeavor to describe some of the plants which I have designed and which comprise foundries devoted to the casting of the smallest forms of large sections with practically no core work, to the most specialized shops using machines almost exclusively.

For plants engaged in heavy work I have made designs in two ways. In one instance, owing to the form of the site and the location of the railroad tracks, it was found advisable to place the stock house and melting equipment at one end of the foundry, permitting all of the other operations to divide from that point as a basis. For this shop a straight open building, three bays in width, was built, the second bay having been provided with cranes of sufficient capacity to handle the largest ladles, as in this case the work was such that the ladle of iron was the heaviest thing to be handled. Single rail electric travelers were also installed in the main and side bays, provided with suitable wedges to facilitate their movement from one department to another. In addition to serving the foundry these trolleys were used for cleaning up and for conveying scrap, sprues, gates, etc., from the foundry to the stock house.

The melting equipment was in the middle of one end of the foundry and was separated from it by a brick wall. The spouts of the cupolas projected through the latter and were adjustable so that large or small ladles could be filled at any distance from the furnace. The brick wall also kept the slag fumes out of the foundry and the drop was likewise confined, which made the work of cleaning up comparatively easy. The cored and small work was done close to the cupolas, while the large work, on which the temperature of the iron could vary considerably without affecting the castings, was placed where most convenient. It is unnecessary to state that such work as required the use of cranes was done in the middle bay.

The cleaning department was located at the end of the building opposite the cupolas, partly in the center and partly in the side bays, the design being such that as the foundry increased its output the building could be increased in length and the cleaning equipment moved along to provide additional molding space. With the growth of the plant in view, mills, grinders, and the sand blast machine were placed as far down as possible, that they need not be moved until the second extension to the foundry was made. The contour of the site was such that the waste material could be moved out of the side and end of the shop for filling purposes.

Owing to the peculiar location of the railroad tracks, the stock house was placed across one end of the building and the track was extended up to the charging floor, making it possible to unload several carloads of coke and iron on to this floor. The space underneath the trolley was utilized for the storage of iron, coke, sand, fluxing material, etc., and the whole was enclosed by a like building which contained a single rail electric traveler for handling material to the cupolas and the foundry, and which connected with the trolleys in the latter.

The main building was of steel frame construction, with brick curtain walls, and was provided with a wooden roof covered with slag roofing and with large wooden frame sliding sash

windows. The floor of the foundry consisted of molding sand laid on filling, although no pit work was done. Ventilators with tilting sash operated from the floor extended practically the width of the center bay, and while there were no skylights, sidelights were depended upon for all of the illumination, the windows having been carried as high as possible for this purpose. Large galvanized iron ventilators were placed in the roof at every other bay, to provide for the circulation of air when not pouring and in inclement weather.

The foundry was about 350 ft. long, and if it were increased in size to make other melting equipment necessary, the cupolas would be installed at one side sufficiently far down to conveniently distribute the iron according to the varying classes of work to be poured. It is not probable, however, that this will be done, as there seems to be no reasonable limit to the distance which a ladle of iron for heavy work can be carried.

A foundry of another type for the production of medium and large machinery castings, with a fair proportion of cored work, was laid out partly in accordance with the contour of the site on which it was located, due regard being given to the location of the railroad tracks. This foundry was of the usual three-bay type, having one large center bay and two smaller ones on either side. The stock house was placed at one side of the property adjacent to the railroad track and contained all of the raw materials except the iron, which was carried in the yard commanded by a crane. The stock house has an elevated track extending through it, that all supplies could be dumped by gravity from the cars in which they were received and thereafter conveyed under cover into the foundry. This stock house need not darken the side of the foundry which it adjoins, since it can be located far enough away to permit the placing of windows down to a level about seven feet above the floor, with a light well at least 12 ft. wide. In any event it makes little difference whether the light is somewhat obstructed on that side, since the melting equipment occupies some of it, and with a foundry for this class of work there are core ovens, drying ovens, sand mixers, core storage, core making, and other departments which do not require much light, while others can be suitably lighted by skylights.

The coke is raised to the charging floors on cars by means of a plunger elevator, while the iron from the stock yard is carried by a single rail traveler directly on to the charging floor.

Both the melting and cleaning departments are fixed points in this scheme, the foundry with its stock house and yard growing away from these departments, and additional melting equipment can be placed in the side bay if required.

Cleaned castings are stored in a yard or building at right angles to the foundry, communicating with the machine shops. As there is considerable core work a large amount of refuse has to be elevated by cheaply built conveyors to a set of overhead bins, discharging into cars or wagons.

Since a foundry of this type will have some pit work, the flooring will naturally consist of sand to a considerable depth with brick or concrete floors in the cleaning department. The cleaning floor space will absorb some of the molding room as the foundry is extended, but otherwise this department will not be disturbed.

This type of plant presupposes a large establishment divided into departments, castings being made at the option of the foundry rather than in response to some demand from the machine shops. This plant is to be built with masonry walls having a wooden roof covered with slag or gravel, wooden window sash, partly sliding and partly tilting, large monitor with tilting sash, galvanized ventilators, core room partitions fire

proof, and with floors in front of the drying ovens and the core room of concrete construction.

Another type covering several classes of large work is designed to grow in two directions, being devoted to a large amount of chilled work. The melting equipment, including air furnaces, is located in the center of the building, and the space immediately in front is occupied by the ladle and chill storage and ladle mending departments. Inasmuch as the molds for the sections made in this plant are cast on end, a proportionately greater tonnage can be secured from a limited floor space, as compared with a plant where floor molding is done exclusively. Considerable room is required in a shop of this kind for handling ladles. Separate power cranes are also required for each pit and liberal head room is necessary. The floor about the pits in front of the drying ovens should be made of concrete. The growth of the other end of the plant devoted to the production of general castings will be similar to that of the large foundry already described.

A plant of this kind may be divided into three or more bays, the furnaces being so located that they are accessible to the main bay cranes. The stock house and iron storage may be located as previously explained. The charging floor, on account of the cupolas necessary to supply all of the mixtures required, should be served by an overhead crane which can carry large pieces of scrap and carloads of pig iron to any cupola or furnace.

While the area required per molder in lighter gray iron work may be as great or even greater than in heavier work, the tonnage handled is proportionately much smaller. Frequently no overhead equipment is required, tracks or trucks being amply sufficient for handling the iron. Certain floors may require comparatively large amounts of iron and separate handling appliances, but in general the buildings will be divided into bays, with the melting done at one end or one side and the cleaning department directly opposite. The pickling department should be located away from the natural line of growth so that extensions will not disturb this department. For this class of work the core room can be established at a distance from the foundry and it is not essential to have it directly in or adjacent to the foundry building.

The stock sheds and iron storage should, of course, be convenient to the melting department and the overhead crane is not essential to the iron yard. Tracks and cars connecting with the elevator are as economical as a yard crane, when all of the handling is considered. A separate building should also be provided for the storage and repair of molding machines.

In a foundry of this type it will be found necessary to install light overhead travelers which can serve either the molders or the machines and which, in any event, can handle the iron. Considerable space is also necessary in a plant of this kind for stacking flasks, as it is not practical to have a large flask yard or to build a separate structure for them. Galleries can be used very well as storage room.

Foundries equipped with machines for special work will next be considered. They can be built several stories in height with a foundry on the upper floor and the other departments underneath; or where there are a number of foundries in a group, the buildings should be two stories, with a foundry on the top floor. The various foundry buildings should be located so as to conveniently receive their supplies from one stock house and their cores from another, with a pattern storage and repair department over one or the other of these buildings. The buildings should be designed with sufficient head room in the lower story to accommodate large tumbling mills with a platform over them for suitably distributing stock, the mills being high enough to

dump their contents either into barrels or on to conveyors. A floor should also be provided for the foundry with a frame for a suitable grating through which the sand can be dropped and on which castings can be piled after shaking out.

The roof should have sufficient strength to support travelers for carrying the molds and iron, and all bracing should be kept above the trusses as far as possible to provide for conveyors for handling sand to the molding machine hoppers. The trusses should be designed with a stiff lower chord and should be of such form that the apparatus may be fastened to it anywhere without punching or drilling. A durable floor can be made of paving brick laid on planks with a cushion of sand, the planks having previously been covered with a waterproof material to prevent dry rot. A floor of this kind can be changed for any purpose more easily than one of steel or concrete and is furthermore much lower in first cost.

The castings are dropped through chutes in the floor to the mills below, where the sorting, cleaning and grinding are done, although a certain amount of sorting can be done on the foundry floor by judiciously locating the machines on similar work.

Plants for highly specialized work, involving carriers for handling molds, flasks, castings, etc., will next be considered. There are two types, one with the building two or more stories in height, with a carrier on the upper floor, while the other has the carrier and the other departments on the ground floor. The price of the real estate and the size of the cores largely govern the design of a plant of this kind, as the output is large in volume and must be handled by conveyors, and there is little advantage in the use of gravity.

I have built plants of both types and have found either well suited for the work for which it was planned. In one case the core room and core storage were located so that the cores for all classes of work could be placed on the carrier with a minimum amount of handling and each car of the carrier brought a fresh core to replace the one taken away. All departments, including the cleaning room, were on the ground level. Such a plant requires a large amount of light and ventilation and windows and skylights are placed wherever possible. The floors are preferably of concrete, as practically no sand collects upon them, and as the pouring is done while the flasks are in motion on the carrier, there is little danger of spilling or splashing iron. In another plant producing very small castings the carrier was placed on the second floor and the finished sections were delivered by means of a conveyor through a separator and cooling tank to a continuous cleaning apparatus on the first floor. The cores were handled in trays.

The roof of such a foundry should be very heavy and substantially braced in all directions, as it must support considerable overhead conveying apparatus for the handling of sand with concentrated loads at various points where the sand happens to be located. The floor should be of brick or concrete, preferably the former, for reasons which I have already given. There are no great floor loads with carriers, but a complicated flooring system is usually necessary on account of many conveying devices which are used. In the construction of buildings brick walls, either with or without steel columns for supporting the trusses, have been used.

There are other forms of wall construction from which choice can be made, such as reinforced concrete, concrete plaster on wire lath, concrete blocks, terra-cotta hollow blocks with or without steel reinforcing strips, brick, corrugated iron and wood. The last two are rarely used at present, wood being objectionable on account of the fire risk, and corrugated iron in view of its short life. Of the other materials the question of relative cost is a large factor, and

a suitable selection must be made to fit the case in hand.

I have always presented plans of all my buildings to the reinforced concrete contractors, that they might compete with the other forms of construction, but I have not yet been able to secure a bid or to have a building built as cheaply by them as from other materials, and when I say this I accord due appreciation to the question of insurance, as locality and contents are considered by the underwriters as well as the type of the building.

I am somewhat opposed to reinforced concrete on account of its lack of what I term "manufacturing elasticity," since it does not adapt itself very well to alterations and extensions which are constantly being made in plants devoted to foundry work. Brick, concrete blocks, and hollow tile are the most adaptable, brick probably being more so than any of the others. Considering the present price of brick, no saving can be effected by the use of the other two forms of covering, although in the large foundries to which I refer, the weight of the steel can be maintained at the minimum by the use of hollow tile above the windows.

For interior partitions hollow tile makes a firm, cheap wall. Concrete plaster on wire lath, expanded metal, or galvanized netting usually requires so much supporting steel that it is quite expensive and practically costs more than brick and does not possess the advantages of the latter.

Steel roof trusses should be carefully designed so that they may be conveniently reached with cleaning and paint brushes, especially in foundries of the continuous type, where considerable vapor arises from the cooling sand. The trusses and columns should be carefully and thoroughly painted. Roofs are cheaply constructed of wood, with slag or gravel covering. This covering is favored in view of its low first cost, as against slate, tile and special forms of reinforced concrete. I have had only one disastrous experience with a roof of this kind and that was due to the fact that the sprinkler system had not yet been connected.

Windows except where there is an exposure, are generally made with wooden frames, glazed with factory ribbed glass and should be fitted to tilt, thereby securing the greatest possible opening. There was at one time a craze for making walls almost entirely of glass and steel. These buildings, however, are difficult to heat in winter, and to ventilate in summer, while the glare of the direct sunlight is most unpleasant. Many plants of this kind have adjusted curtains to the windows and have glazed portions of the windows, and in some cases large sections have been removed.

A building wall containing 50 per cent. of window space will usually be very completely lighted for any width of structure and in any event passages and storage departments can be placed in the darker sections.

I am an advocate of metallic bars and ribbed glass for skylights, and in continuous foundries where a large amount of vapor is present a copper bar is cheapest in the end.

All of the floors I have described have been used successfully, but there is one type that I have not referred to and which is built of ordinary brick, with rails laid thereon, over which the flasks of the machines can be moved as the case may require. The rails should be laid down on sleepers in a sub-base of concrete, if this floor is on the ground level. The floor of the charging departments should be made of steel plates without tracks or in fact any ridges of any kind to interfere with the free movement of trucks and the use of shovels or forks. The cupolas should be set fairly high so that a man may work conveniently under them and to facilitate also the handling of ladles of various sizes. This is

especially a desirable feature for continuous foundries where a ladle reservoir is provided with a skimming device which is located between the cupola and the pouring ladle.

The charging door I usually make very large, with a heavy cast-iron curb, that a truck of scrap or coke may be run right up to it and dumped in. The opening is best protected by a wire screen raised and lowered by counterweights. The installation of spark deflectors depends somewhat on the location.

I sincerely hope that some one will soon devise a practical cupola blast regulator. I have some ideas on the subject myself, but have been too busy to develop them.

Depending on the work, I advise from 11 to 14 ft. above the tuyeres as the proper height of the opening in the cupola for economical and rapid melting. After considerable experience with tuyeres of various types, I still adhere to the old-fashioned square box tuyere as being the most reliable and efficient. Blowers vary in accordance with the service they are to render, my preference being for a positive blast blower for cupola work, with independent engine or motor, as circumstances may dictate. The motor should be provided with a speed regulator to control the melting, the latter being imperative for continuous practice. For air furnaces the centrifugal blower seems to be best adapted, a simple unloading device being sufficient for its regulation. It is, of course, needless to say that the larger the fan within reasonable limits, the smaller the consumption of power.

I also advocate the slagging of the iron as the melting proceeds, and the tonnage of the heats will naturally indicate whether or not a special conveying apparatus should be used for handling this slag. A wheelbarrow is, of course, the simplest device.

The coke should be kept under cover and handled as little as possible. Scrap should be handled according to its nature, as no single method will answer for all grades, although the magnet seems to be more adaptable than any other method. A system of handling pig iron will depend upon the amount consumed. Small quantities for small cupolas which must be broken can be handled more cheaply by common labor, while large tonnages offer a prolific field for the use of a magnet and adds considerably to the storage space. I have yet to be convinced of the value of a cupola charging machine. Storage yards for charging materials should be served by an overhead crane and industrial tracks should be used as little as possible.

Plunger elevators are best adapted for charging floor service. Whether the machine should operate directly by hydraulic pressure or with some elastic medium interposed between the water and the source of power will depend largely upon conditions. In large foundries and especially for continuous work, I usually provide a speaking tube between the melter and the charging floor that the chargers may supply coke in accordance with the demand for iron from the floor. From this you can see that the melting ratio is of comparatively little importance in this work, when compared with the cost of a completed mold. Frequently the core alone costs several times more than the coke employed in melting the iron.

For handling large flasks I prefer a locomotive crane, as it gives the greatest flexibility with the lease expense. The practice of running an overhead crane through an opening in the end of the building is very expensive and unsatisfactory, requiring as it does expensive building construction. It is furthermore impossible to keep tight against the weather while the flask yard is limited to the space directly in line with the crane runway and generally in line with and

obstructing the growth of the foundry. By the use of the locomotive crane a site of any shape can be utilized and the crane can enter the foundry at almost any point. As it is operated by steam, it can be driven independently of the plant. For indoor flask storage, trucks and elevators provide convenient means for handling.

Belts of a liberal size with bucket elevators are best adapted for handling sand when it is to be delivered to the various parts of the foundry mechanically. Belts may safely be used for receiving hot sand dumped out of flasks, though containing many sprues, much shot and chaplets. Belts also may be used for handling flasks in continuous work even though they are hot and of considerable weight. I also advocate sand riddles with bronze wire, as it lasts longer than iron, steel or brass. Wood or reinforced concrete is the best material for sand hoppers, conveyor troughs, etc.; while all the advantages are in favor of wood.

In designing continuous systems, whether wholly or partly automatic, care should be taken to keep the various operations independent of each other that any interruption to any one may not affect the others. The efficiency of this method of producing castings depends largely on the care given to this feature. I have known of some who have failed entirely as a result of the too close adjustment of the various operations, whereas a little room between them would have made the plant a success.

Core rooms naturally depend on the nature of the work. For large and intricate work they should be located in the foundry, while others can be placed in separate buildings and can deliver the cores to the foundry on conveyors and can later be distributed by boys. For making cores of moderate size to be handled in dryers, I advocate that the benches should be so spaced that the oven cars can operate between them, permitting the finished cores to be placed directly on the cars and when filled they can be run directly to the ovens over suitable tracks. After the cores are baked the cars can be delivered to the core storage room, thus obviating unnecessary handling.

For cores of large or moderate size I prefer an oven which has a long arch at the bottom with fire and combustion chambers underneath and the heat thus radiated will circulate through every part of the chamber. For small cores I had devised an oven heated by oil or gas containing a conveyor. Learning later that the same could not be patented owing to a previous right on a continuous baking machine, I lost interest in the same. A plant which I built has eight of these in operation, using oil in conjunction with waste heat from the malleable annealing ovens.

When cranes and tracks are used, care should be taken to prevent points of congestion at meeting or transfer places.

THE KANKAKEE MARSH in Indiana, long famous as a hunting and fishing resort, is threatened with extinction by a project for the drainage of this great tract. The plan for the work has been developed in the Office of Experiment Stations of the Agricultural Department and provides an increased carrying capacity in the river by straightening its channel. At the present time the river is 72 miles long in the section which will be improved, and it is proposed to shorten this length to 41.8 miles, of which 35.8 miles are in Indiana and the remainder in Illinois. This is to be accomplished by cutting off 84 bends of the present stream by channels varying from 150 to 5,500 ft. in length. The total length of the new channels to be made in this way is 27½ miles, the remainder of the improvement being the canalization of the old river channel.

Book Notes.

Instructors in applied mathematics often find considerable trouble in preparing satisfactory examples for their students to solve. According to the new method of teaching mathematics in our engineering schools, the work is done mainly by solving problems, and it is now expected that all these problems will be drawn directly from engineering practice of one sort or another, so that the mathematical exercises shall also serve in a measure as engineering training. Prof. Ferdinand Wittenbauer, of the Technical Institute in Graz, has published a small volume likely to be of interest to instructors in American colleges. The title is "Aufgaben aus der Technischen Mechanik" and the volume covers forces, centers of gravity, the movement of points, the geometry of motion, dynamics and similar subjects. All of these problems are solved in the manner which the author considers best adapted for purposes of instruction, and on this account teachers in American schools are likely to find additional interesting information in the book. The larger portion of the examples were prepared by the author for classroom purposes, but others have been drawn from books which were written for a similar purpose. The volume will be followed by another containing examples relating to the strength of materials and to hydraulics. (Berlin, Julius Springer, 5 marks.)

A veteran American trade journalist, Mr. Gardner D. Hiscox, has written a book on "Modern Steam Engineering," which is apparently intended mainly for men who aim to become the operating engineers of power plants. The book is mainly a descriptive one, although there is a limited amount of information concerning the theory of steam engines and a large collection of useful tables are given for the assistance of engine room staffs. These tables cover the properties of steam, the dimensions of engine parts as established by leading builders and by steam engineering specialists, and the results of tests of various types of engines and auxiliary apparatus. The volume begins with the properties of steam, and then passes to the types of boilers and their auxiliaries in general use. It then takes up the methods of securing economies by economizers, feed water heaters and other apparatus, and special attention is given to the practice of steam superheating. The operation of steam in the engine is outlined and there is a chapter on the indicator and its uses. The various types of reciprocating engines are explained in considerable detail and the construction of different steam turbines is described. The book is made particularly useful for the class of readers for which it is intended by including chapters on refrigerating plants and on elevators. There is also a section written by Mr. Newton Harrison on the electrical equipment of isolated plants and the methods of looking after it and guarding against troubles. A large number of questions asked by examining boards of candidates for licenses as steam engineers are given in an appendix, together with the proper answers to them. There is also a chapter on the duties of an engineer who is in charge of isolated plants. (New York, Norman W. Henley Publishing Co., \$3.00.)

An unusually timely book is Mr. R. F. Herriek's "Denatured or Industrial Alcohol," which is a general treatise on the history, manufacture, uses and possibilities of industrial alcohol in the countries which permit its use, particularly the United States. It will be recalled that last June Congress passed a law permitting the general use of tax-free domestic alcohol, after it had been suitably denatured. This legislation was the result of a movement which originated several years ago and was fostered by the organized

agitation of a society formed for the purpose. In the congressional hearings the author of this book represented the American Chemical Society and the Society of Chemical Industry. The book contains the information which the author has collated from various publications, particularly the report of the British Departmental Committee on Industrial Alcohol presented in 1905. He has searched the patents in the United States relating to the improvements in the manufacture of alcohol and alcohol distilling apparatus and has carried on various independent investigations. A considerable part of the information is also due to the assistance rendered by specialists who have studied the properties of denatured alcohol and its use in the arts and in internal combustion engines. The author points out that the whole problem of denatured alcohol in the United States is now in a pioneer state and necessarily a large amount of the information concerning this material and the apparatus for using it is derived from foreign experience. He has endeavored to epitomize in this book all such experience which is likely to be of value to American readers, and consequently the book has a special value as a broad survey of the present state of the art. The introductory chapter is devoted to the composition, history and use of denatured alcohol, and it is interesting to observe what a valuable aid in many industrial processes this material has become. The second chapter describes the manufacture of alcohol and points out that some statements concerning the wide variety of materials from which alcohol can be prepared are based on chemical and not financial considerations. While it is true that alcohol can be obtained from many different sources, nevertheless the number from which it may be profitably obtained is not so great as some enthusiasts have suggested. The third chapter is a description of the methods of distilling and rectifying alcohol that have been proposed. Although the processes are not numerous, the apparatus employed in them varies widely. The fourth chapter explains the various methods of determining the properties of alcohol for commercial purposes. In the fifth chapter the cost of its production and of the plants used in its manufacture is discussed in considerable detail. The three following chapters are devoted to an explanation of the uses of alcohol as an illuminant, as a fuel and for power purposes. There is some misconception on all three subjects and the author points out very clearly just what may be expected from alcohol in regular commercial use. The book closes with a summary of the laws and regulations for denatured alcohol and various official papers on the subject. (New York, John Wiley & Sons, \$4.00.)

It has been a matter of considerable surprise to engineers who take up the use of automobiles that no book exists which is a good guide to the owner who cares for and drives his car and is possessed of some intelligence. There are various "catechisms" of which the less said the better, and there are a few fair general books on design and operation, but nothing for the owner who wishes to have a good knowledge of the proper use and care of a car. This really marked gap in automobile literature has been well filled by Mr. Albert L. Clough's compilation of articles from the files of the "Horseless Age" on the "Operation, Care and Repair of Automobiles." The journal mentioned has won first place in automobile circles as the best paper published on the mechanical and operating features of automobilism, and the 343 pages of the book contain the cream of all the good things in it during several years. A large part of the troubles which amateur drivers have with cars are of an electrical nature, and consequently the first third of the book is devoted to a clear and accurate de-

scription of the electrical equipment of small and large automobiles, and the many ways in which they get out of order. This part of the volume is by all odds the clearest and best explanation of the subject in English. Carburation is next taken up and discussed in a general way, which is not quite so satisfactory as the electrical section for some of the common troubles, such as the sticking of the float so that flooding occurs, are not mentioned. These troubles seem so elementary and self-evident to the experienced operator that the perplexity they cause the inexperienced driver is not appreciated. The editor would do well to incorporate in the next edition a statement of the various classes of simple as well as complex troubles due to the carburetor and auxiliaries. If this could be arranged like the diagrammatic schemes of analysis used by chemists it would be of maximum usefulness. It would also be well to describe the carbureters used on the leading cars of moderate price, such as are generally cared for by their owners. Some of these are somewhat difficult to understand without taking them apart, and the descriptions given in catalogues and "instruction books" issued by the makers are generally inadequate. Lubrication and methods of locating abnormal friction in moving parts are well treated, and there is a section on tires which lacks ideal completeness only through the omission of brief notes on the few special types of tires which have some popularity. At this point the plan of the book changes; instead of taking up the steering gear, power transmission details, brakes and other parts by groups, as is done in the parts of the car previously mentioned, they are considered collectively under the head of the inspection, care and use of automobiles. While there is a good index enabling all the information to be readily found, the reader with a logical bent of mind will not care for the arrangement of this part of the book as much as that followed in the earlier sections. There is an interesting section on the washing and shipping of cars and the construction of private garages, but alas, no information is furnished concerning some method of securing one's tools and auxiliaries against the petty but exasperating thefts which seem to be certain to occur in public garages outside of New England. The section on repairs is a good one, but the reader who has not some mechanical skill and plenty of time will do well to leave his important repairs to the local agents of the maker of his car. There is a particularly good article on tools, and the only tool which most owners will probably find it desirable to have in addition to the list mentioned is a very handy special pipe wrench made by the Frank Mossberg Co., of Attleboro, Mass. The book closes with a section on the winter use of cars. (New York, The Horseless Age, \$1.10.)

Letters to the Editor.

DRILLING BLAST HOLES AT HELL GATE, MONT.

SIR:—Since railroad contractors have adopted the use of well drillers for blast hole drilling, there have been differences of opinion as to the best size holes to drill to give the most practical results in springing and shooting and concerning the comparative speed and cost of the drill work itself. The Winston Bros. Co. desiring to test out this matter in a thoroughly practical way, had two drills shipped to Hell Gate, Mont., where they have a large contract and a number of very heavy cuts to make in the solid rock; one of these machines was equipped with solid rods for drilling 3-in. holes, the other was equipped with a heavy string of cable tools for drilling 5-in. holes. The Keystone driller handling the cable tools drilling the 5-in. holes was of the traction type, and the Cyclone driller handling the rod tools drilling the

3-in. holes was of the nontraction type; this item was perhaps overlooked in ordering the drills, as it did not put the two machines on an exactly equal basis; when moving from one hole to another, the traction machine had considerable advantage over the other, as it was able to move in less time.

The drills were started on two lines of holes parallel with each other and 20 ft. apart. The rod drill gained rapidly on the cable drill, finishing its line of holes and drilling one hole on the line of the cable drill, which was an actual gain of two holes. Had the rod machine been a traction outfit, considerable more time could have been made, as it required more time to move the non-traction than it did the traction drill. The holes were sprung after each machine, and the small holes were found to spring much better than the larger ones with the same amount of explosive used in both. This was due to the tamping blowing out of the larger holes, which did not occur in the smaller ones. In a number of holes it was necessary to use short pieces of drive pipe to case off the loose material above. When the shots were fired the amount of energy spent through the opening of the holes was very evident. The drive pipe in the large holes was thrown high in the air, or torn apart, while that in the small holes was not thrown up or damaged. The result from the work done by each was very strongly in favor of the 3-in. holes.

The test was carefully conducted and, the drills being operated by the makers, each machine was worked to its maximum capacity. The material drilled consisted of shales, limestone and conglomerate rock, all of which laid on an angle of about 30 deg. The best day's work for each drill was 73 ft. in 10 hours for the rod machine, and 71 ft. in 12 hours for the cable machine. The writer is indebted to Mr. Gus Young for the greater part of the information; Mr. Young had charge of the drill work and also the blasting.

Yours very truly, W. T. KERSHNER.

Hell Gate, Mont., May 16.

A METHOD OF CALCULATING EARTH VOLUMES.

SIR: Those who have to do with the calculation of earth volumes usually know the various practical principles involved. The calculation of an earth volume is by its nature an approximation. The accuracy of this approximation depends on the care taken in both office and field. A great part of the cost of cross-sectioning and computing the cut or fill by the ordinary methods may be done away with, and the results as ordinarily obtained not appreciably impaired. The following is a method used by the writer to accomplish this purpose.

The average transverse slope of the ground surface, the cut or fill at the center line, and width of roadbed are the factors that enter into consideration. The rectangular figure *R B D C* represents a typical cross-section of a railroad cut where the surface is comparatively uniform. The section *R O B* represents the cross-section of the "grade prism." If we assume a set of coordinate axes as indicated, having *O* for their origin, there results for the two straight lines:

$$O D \quad y = m x \quad (1)$$

$$C D \quad y = n x + b. \quad (2)$$

where *m* and *n* are respectively the side and surface slopes. The point of intersection has for its abscissa:

$$x = b \div (m - n). \quad (3)$$

The area of the triangle on the right of the axis of *y* ordinates is $\frac{1}{2} b^2 \div (m - n)$.

In the same way the area of the triangle on the left of the axis of *y* ordinates is $\frac{1}{2} b^2 \div (m + n)$. Calling the areas *A_r* and *A_l* there results for the sum of the two:

$$A_r + A_l = b^2 m \div (m^2 - n^2). \quad (4)$$

Suppose we assume the length of the prismoid

TABLE A FOR $m = 0.667$.

W	12	14	16	18	24	30
V _g	89	121	156	200	355	555
W	12	14	16	18	24	30
P	4	4.67	5.33	6.00	8.00	10
n	1	1	100	100	100	100
	m+n	m-n	(m+n)	(m-n)	(m-n ²)	(m-n ²)
0	1.50	1.50	2.778	2.778	5.556	.926
02	1.46	1.55	2.697	2.864	5.561	.927
04	1.41	1.60	2.620	2.955	5.575	.929
06	1.38	1.65	2.548	3.053	5.601	.933
08	1.34	1.70	2.480	3.157	5.637	.939
10	1.30	1.76	2.485	3.267	5.682	.947
12	1.27	1.83	2.354	3.387	5.741	.957
14	1.24	1.90	2.296	3.516	5.812	.968
16	1.21	1.97	2.240	3.655	5.895	.982
18	1.18	2.05	2.187	3.805	5.992	.999
20	1.15	2.14	2.137	3.968	6.106	1.018
22	1.13	2.24	2.088	4.146	6.234	1.039
24	1.10	2.34	2.042	4.340	6.382	1.063
26	1.08	2.46	1.998	4.554	6.552	1.092
28	1.06	2.58	1.956	4.789	6.745	1.124
30	1.03	2.73	1.916	5.050	6.966	1.161
32	1.01	2.88	1.877	5.341	7.218	1.203
34	.993	3.06	1.840	5.668	7.508	1.261
36	.974	3.26	1.804	6.038	7.842	1.307
38	.955	3.49	1.770	6.459	8.229	1.371
40	.937	3.75	1.736	6.944	8.680	1.480
42	.920	4.05	1.706	7.507	9.213	1.530
44	.903	4.41	1.669	8.169	9.838	1.639
46	.887	4.84	1.644	8.959	10.603	1.767
48	.872	5.35	1.615	9.942	11.557	1.926
50	.857	6.00	1.587	11.110	12.697	2.116
52	.842	6.82	1.560	12.63	14.100	2.365
54	.828	7.80	1.535	14.620	16.155	2.692
56	.815	9.37	1.510	17.350	18.860	3.143
58	.802	11.53	1.485	21.350	22.835	3.806
60	.789	15.00	1.462	27.700	29.222	4.870

$$1.852 \left(\frac{2m}{m^2 - n^2} \right) \frac{1}{6}$$

Each one of the three terms can be obtained in this way. The second term must be multiplied by 4. Prismoidal formulæ corresponding to (5) and (6) may be derived in a similar way.

To illustrate the difference between the volumes given by the average end areas and by the prismoidal formula we may assume the following conditions:

Sta. 17.—Center cut, 8.5, transverse surface slope, $n = 0.24$.

Sta. 18.—Center cut, 1.8, transverse surface slope, $n = 0.14$.

Assume the side slope $1\frac{1}{2}$ to 1 and the roadbed 16 ft.

At the top of Table A we notice that the altitude of the grade prism is 5.3 ft. Then

$$V_{18} = 5.812 (1.8 + 5.3)^2 = 293$$

$$V_{17} = 6.382 (8.5 + 5.3)^2 = 1215$$

$$\frac{1}{2} (V_{18} + V_{17}) = 754 \text{ cu. yd.}$$

So far we have computed the volume as given by the average end areas. The same by the prismoidal method would be:

$$1.063 \times 13.8^2 = 202 \text{ cu. yd.}$$

$$0.918 \times 7.1^2 = 49 \text{ "}$$

$$4 (1 \times 10.4^2) = 433 \text{ "}$$

$$\text{Total} \dots\dots = 684 \text{ cu. yd.}$$

In order to get the true results for cut, it would be necessary to subtract the volume of the grade prism, 156 cu. yd., which is also found at the top of Table A, from both results. The volume obtained by average end areas may be either too great or too small. When the transverse slope of the ground is uniform between stations the prismoidal volume will be the greater. When the ground surface is badly warped between stations the volume as given by average end areas will be greater. The maximum error by the average end area method will occur when the work is changing rapidly from cut to fill. The effect of a change in the transverse slope may have two results: it may tend to increase the error or diminish the error. When the transverse and longitudinal slopes of the ground both increase or decrease, the changes affect an increase in the error. When the two changes are opposite one affects an increase and the other a decrease in the error. In general it is not the irregularities in the surface of the ground that make most earthwork calculations unsatisfactory from the contractor's point of view, but rather the more general topography of the surface. When the number of sections in the field are doubled the error produced by figuring with the average end areas will be approximately divided by two. When the grading of several miles of road is under consideration at one time the percentage of error will be greatly decreased. The results obtained for the total excavation or fill will not be greatly different by the prismoidal and average end area methods. On the other hand, when the material changes from place to place and it becomes necessary to know more accurately the excavation over small distances, the prismoidal formula is the only one that will give practical results.

Yours truly,

East Berlin, Conn. G. L. BILDERBECK.

THE SOO CANALS, American and Canadian, carried a total freight traffic of 51,751,080 net tons during the season of 1906, an increase of 17 per cent. over the business of 1905. The total number of passengers in vessels passing through the locks was 63,033, an increase of 16 per cent. over the record of the previous year. The American canal handled 87 per cent. of the freight and 49 per cent. of the passengers.

to be 1 ft. perpendicular to the section shown, then the volume corresponding to each of the cases above will be:

$$V_R = \frac{1}{2} b^2 l \div (m - n) \quad (5)$$

$$V_L = \frac{1}{2} b^2 l \div (m + n) \quad (6)$$

$$V_T = b^2 l m \div (m^2 - n^2) \quad (7)$$

The first two formulæ would be of use when the transverse slope of the ground changes abruptly at or near the center of the roadbed. It would be necessary in all cases to subtract the volume of the grade prism, the end area of which is shown BOR. This may be done for any prismoid or any number of prismoids at once. The volume of the grade prism depends on the width of the roadbed and the side slope, m . Designating the volume of the grade prism by V_g we may put

$$V_g = \frac{1}{4} l w m. \quad (8)$$

When l is constant this volume depends on w and m . The values of V_g for l equal to 100 and for different values of w and m have been written in connection with Table A inserted here to aid in computing formulæ (5), (6) and (7). It contains but one value of the side slope, namely, where m is equal to 0.667 or as ordinarily designated, $1\frac{1}{2}$ to 1. In the complete form the table should contain several values of m . The length of the prismoid, l , is taken as 100 ft. In any given case where the side slopes are to be $1\frac{1}{2}$ to 1 we may find for any value of n the factor $100 m \div 27 (m^2 - n^2)$.

Then V will equal b^2 times the tabular value.

From the present condition Table A might be worked up to include the quantity b . But such a procedure could hardly be justified, especially for those who use the slide rule for all work of this kind. When it is desired to find the volume V_R or V_L the factors $100 \div 2.27 (m - n)$ and $100 \div 2.27 (m + n)$ are found in the table, so that $V_R = b^2$ (tabular value) and $V_L = b^2$ (corresponding tabular value).

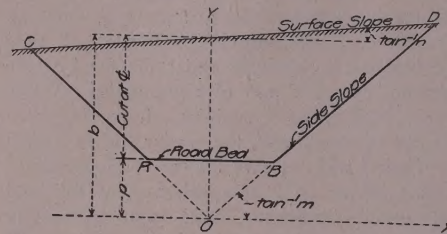
The factors $1 \div (m - n)$ and $1 \div (m + n)$ are also given in the table, so that the distances out to the intersection of the side slope and the surface may be found and are expressed by $x_R = b$ (tabular value) and $x_L = b$ (corresponding tabular value).

The results so far have had to do with volumes only as given by end areas times lengths. The volume of a prismoid such as would occur in practice, given by this method, would be incorrect. The error incurred by using it will vary from one to 50 per cent. of the value of the prismoid. The formula generally used and the

one universally admitted to be the best for computing volumes of this kind, is known as the three-area prismoidal formula. Its form is very common:

$$V = l \div 6 (A + 4A' + A''),$$

where A is the area at one end of the prismoid,



A'' is the area at the other end, and A' is the area of the section midway between the ends.

The reader will notice a similarity of this formula to many other formulæ in applied mathematics, Clapeyron's theorem of three moments, Simpson's rule for areas, etc. It is derived di-

rectly from the expression $\int_0^1 A dx$

where $A = K + K'x + K''x^2$, K , K' and K'' being constants. It follows that when we can express the area of any solid as a function of the first and second power of the distance of that area from one of two parallel bases of that solid, the formula as given above will give the correct results. Geometrically, when a solid may be generated by a straight line moving on parallel plane figures as directrices, or when a solid may be generated by an area moving parallel to itself and having its boundary made up of curves of the second degree, the prismoidal formula will give the correct results.

In the prismoidal equation we have:

$$V = \frac{1}{6} l A + \frac{4}{6} l A m + \frac{1}{6} l A''.$$

The volume then will be made up of three separate terms and the finding of these terms may be facilitated by the use of Table A. For instance, considering the first term, and substituting for A its value in terms of m , n and b :

$$\frac{1}{27} \left(\frac{l}{6} A \right) = 1/27 \times \frac{1}{6} \times 100 \times \frac{1}{2}$$

$$\left(\frac{1}{m-n} + \frac{1}{m+n} \right) b^2 = 1.852 \left(\frac{2m}{m^2 - n^2} \right) b^2/6.$$

When m is equal to 0.667 and for different values of n Table A gives the factor,